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ABSTRACT

Listed in this syllabus are concepts and understandings in four areas dealing with science, technology and society: (1) relationship of science and technology; (2) the nature of technology; (3) the interaction of science, technology, and society; and (4) making decisions about technology. Included with these concepts and understandings are questions for students to answer, and when applicable, a code to an activity presented in an appendix. Program objectives and performance criteria are provided for each of the areas, as is a list of 23 science processes keyed to the activities. Four appendices are included. Appendix A contains the activities (cross-referenced in the concept/understanding outline). All of the 56 activities (designed to assist students in attaining the program objectives) include a list of materials needed, procedures, and discussion of results. Appendix B contains two readings. Appendix C contains excerpts from a National Science Teachers Association position statement "Science-Technology-Society: Science Education for the 1980s." Appendix D provides information about problems and problem-solving processes. (JN)

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SCIENCE, TECHNOLOGY, AND SOCIETY

BLOCK J

Science Syllabus for Middle and Junior High Schools

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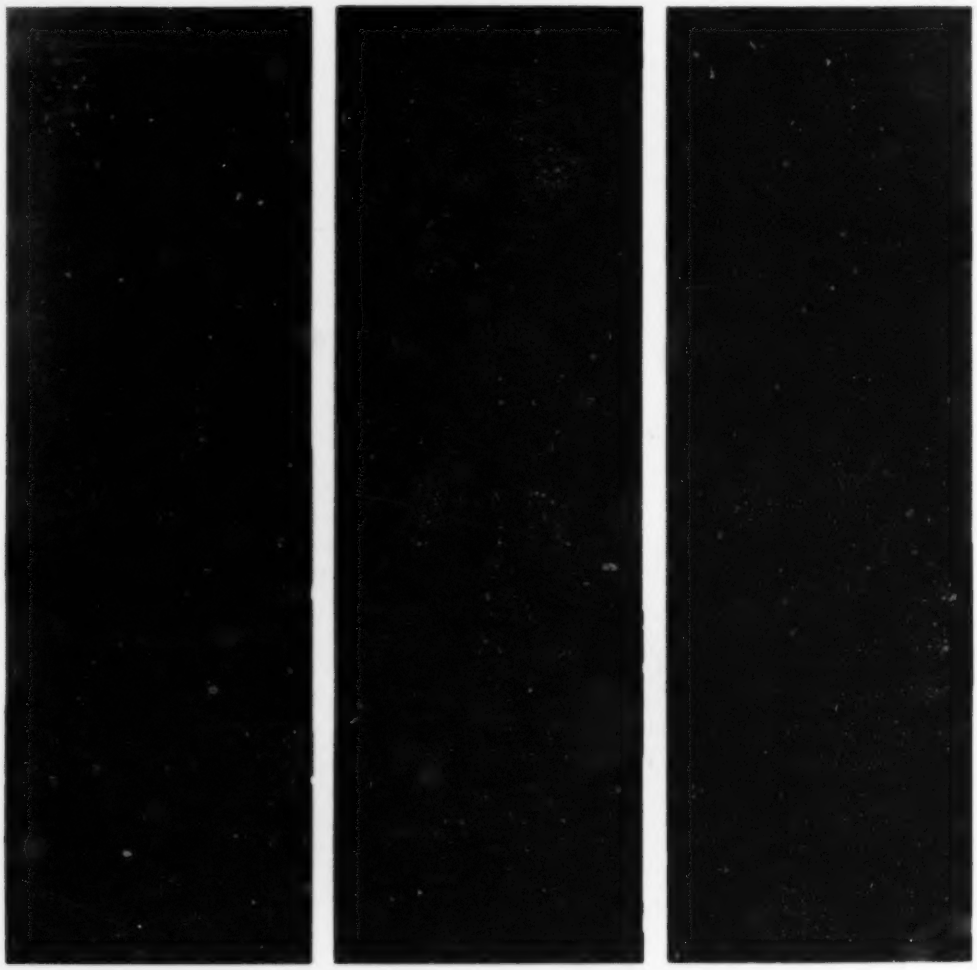

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SCIENCE SYLLABUS FOR MIDDLE AND JUNIOR HIGH SCHOOLS

BLOCK J: SCIENCE, TECHNOLOGY, AND SOCIETY

The University of the State of New York
The State Education Department
Albany, New York 1985

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FOREWORD

This publication is the tenth and final product of the project to significantly update and reorder the Science Syllabus for Middle and Junior High Schools. The project will result in a group of instructional blocks encompassing the content and skills in the biological, physical, and earth sciences appropriate for those grade levels.

The understandings, questions, and learning activities in this publication have been enhanced by the inclusion and referencing of program objectives, performance criteria, and process skills which serve to focus student achievement.

The objectives and performance criteria are provided in a general outline which conforms to the content subdivisions in the publication. Process skills are keyed to the learning activities (**Appendix A**), and the learning activities are keyed to the understandings and the questions.

Resources related to these activities are found in **Appendix B**. Excerpts from the National Science Teachers Association Position Statement, "Science-Technology-Society: Science Education for the 1980s" are provided in **Appendix C**.

A draft of this publication was put together by **Patricia Pietropaolo,** Community College of the Finger Lakes, from material contributed by the following individuals: **Dr. Joyce Swartney**, State University College at Buffalo; **Dr. Burton Voss**, University of Michigan; **John Roeder**, The Calhoun School; **Dr. Bruce Tulloch**, Packer Collegiate Institute; **John Maryanopolis**, Scotia Glenville Central School; **Dr. Dorothy Rosenthal,** Rush-Henrietta Central School; **Sally Maxson,** Canandaigua City Schools; **Janice Bryant**, East Bloomfield Central School; **Ronald Selvaggio**, Fairport Central School; **Dr. Sam Alaimo**, Kenmore Union Free School; **Marie Algera**, Williamsville Central School; **Kathaleen R. Burke**, Buffalo City Schools; **Donna E. DeSeyn**, Fairport Central School; **Angela Jost**, Akron Central School; **Dr. Thomas Kinsey**, State University College at Buffalo; **James W. Lehmann**, Tonawanda City Schools; **Dr. Kathleen Mallea**, State University College at Buffalo; **Ann Michael**, Buffalo City Schools; **Jan Reilly**, Williamsville Central School; **Christine Bosinski,** student, State University College at Buffalo; and **Mary Stein**, student, State University College at Buffalo.

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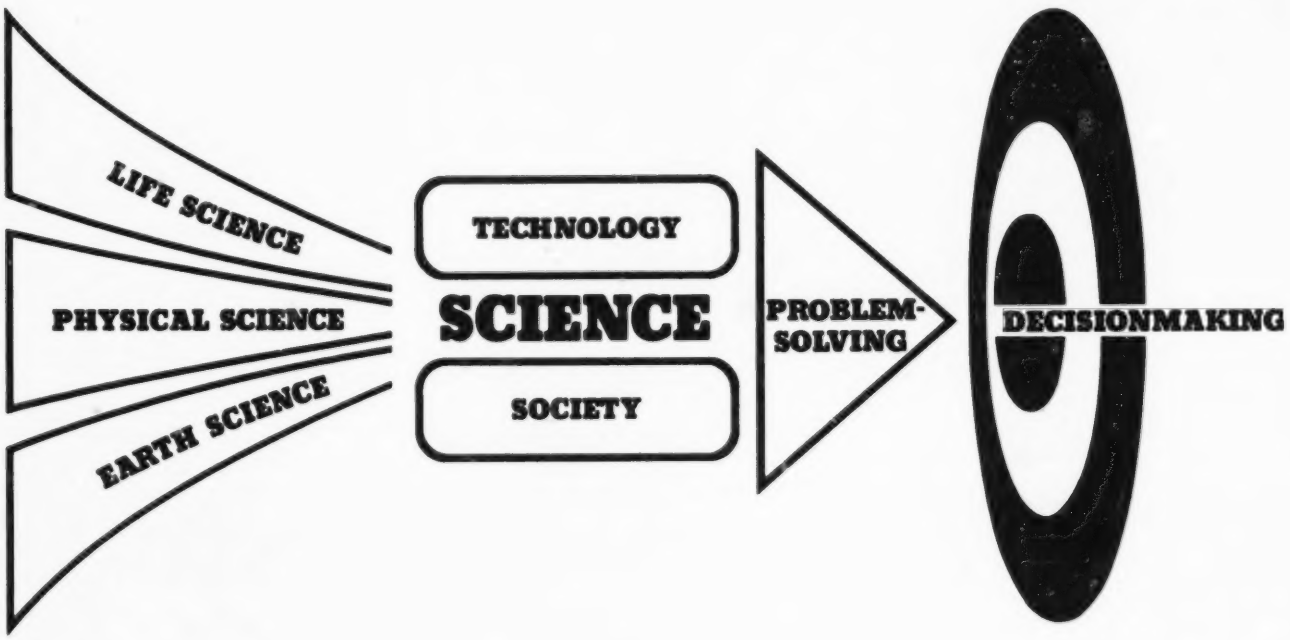
INTRODUCTION

Instruction in science, technology, and society has recently received renewed attention in science education. The National Science Teachers Association (NSTA) defines the goal of science education for the 1980s as the development of scientifically and technologically literate individuals who understand how science, technology, and society influence one another and who use this understanding in their everyday decisionmaking. (Excerpts from the NSTA position statement, "Science-Technology-Society: Science Education for the 1980s" are reprinted in **Appendix C**.) In keeping with this goal, this block is intended to help students:

- understand what science and technology are, and how they interact with one another and with society, and
- use this understanding to solve problems and make decisions at home, in school, in the neighborhood, and in the community

IMPLEMENTING THIS BLOCK

Block J is intended to be used in conjunction with and as a supplement to the other middle/junior high school science syllabuses (Blocks A through I). The concepts and understandings and the activities in Block J should be infused into the instructional program already in place in the areas of life, physical, and earth science. There is a wealth of technological processes and devices that are based on scientific principles from each of these science disciplines. One possible instructional approach is shown by the following model.



Instruction can begin in the area of science, of technology, or of society. Possible infusion strategies include:

1. Starting with scientific concepts and principles (the basic science), then proceeding to:

- the technological processes and devices that either arose from the science or allowed the science to be discovered
- the interaction with society (societal problems and issues)
- problem-solving and decisionmaking

2. Starting with technological processes and devices, then proceeding to:

- the basic science on which these technological processes and devices are based
- societal problems and issues
- problem-solving and decisionmaking

3. Starting with societal problems and issues, then proceeding to:

- the technological processes and devices behind these problems and issues
- the basic science on which the processes and devices are based
- problem-solving and decisionmaking

To help in the task of infusing Block J into the other blocks, these aids have been provided in Block J:

1. Many Block J concepts and understandings have several **examples** of the concept or understanding listed below them (set off by the symbol "•"). These **examples** are intended to illustrate the concept or understanding **for the teacher** and are not concepts and understandings themselves. The examples may be used with students as appropriate. The teacher should also substitute other examples which are deemed appropriate.

2. Many of the Block J activities are extensions of activities in other blocks. If a Block J activity is an extension of an activity in another block, this is indicated in the Block J activity title.

3. Many activities from the other blocks can be used as is or can be easily modified to provide instruction in science, technology, and society understandings. These activities are indicated under the "Questions and Activities" column in the "Concepts and Understandings."

In addition, you may wish to consider the following in implementing Block J:

1. A matrix such as the sample provided can help you see where you are infusing Block J across your science 7, 8, and 9 program. The concepts and understandings from Block J can be listed in the left column, with the program activities across the top.

Block J — Concepts and Understandings	Activities/Grade												
I.A. 1. Science and technology are human endeavors													
2. Definition of science													
3. Definition of technology													
I.B. 1. Science leads to technology													
2. Technology leads to science													
3. Technology is based on scientific principles													

2. Technology includes not just the "big things" — those which are the focus of societal issues — but also the "little things" that people do every day:

- how a youngster repairs a bicycle or toy
- how dishes are stacked for drying
- how clothes are arranged in a closet or drawer

Since these kinds of examples are in the world of your students, try to use them in your instruction.

3. Use Block J as an opportunity to learn from your students and to let them learn from each other. They may have knowledge of some kinds of technological processes and devices which are not in your experience.

4. Remember that decisionmaking implies attitudes and values, and that students will make decisions based on their own attitudes and values, not on yours. The decision you would make in a given situation may not be the one your students would make. However, students should be able to state their attitudes and values and support their decision based on those attitudes and values.

5. The opportunities for interdisciplinary instruction in science, technology, and society are limitless. If possible, work with the technology teacher and the social studies teacher to team-teach science, technology, and society understandings. (The National Council for the Social Studies has issued a position statement on science and technology, "Guidelines for Teaching Science-Related Social Issues." Contact the National Council for the Social Studies, 3501 Newark Street, N.W., Washington, D.C. 20016.)

6. New technological issues arise every day. By bringing the newspaper and television news broadcasts into your classroom, you will keep students interested and your topics current.

Problem-Solving and Decisionmaking

When people engage in science and in technology, they engage in problem-solving and decisionmaking. When people grapple with societal issues arising from science and technology, they also engage in problem-solving and decisionmaking. For these reasons, it is important that, as often as possible, students be given the opportunity to learn to solve problems and make decisions as part of their science instruction.

This opportunity occurs whenever students are provided with experiences in the natural world. If experiences are used to make students aware of discrepancies, they will then raise questions and seek answers, both about natural events and about technological problems and issues.

More information on problem-solving and decisionmaking can be found in **Appendix D**. It is taken in part from the *Elementary Science Syllabus* (1985) and should help you incorporate problem-solving and decisionmaking into Block J and the other blocks.

PROGRAM OBJECTIVES AND PERFORMANCE CRITERIA

The program objectives and performance criteria below are provided as an aid in ordering the direction and synthesizing the outcomes of the instruction related to this block. The objectives and outcomes (performance) described below for this program are merely illustrative, and, as such, they permit latitude in the selection of additional content. It is implied that student knowledge, understanding, and skills accrued as a result of content selection and instruction will be demonstrable in the manner, and to the minimum extent, described.

I. RELATIONSHIP OF SCIENCE AND TECHNOLOGY

PROGRAM OBJECTIVES	PERFORMANCE CRITERIA
The student will be able to distinguish between "science" and "technology."	Presented with verbal and/or visual situations in which people are engaged in science or technology, the student will distinguish which situations are science and which situations are technology.
The student will be able to identify the scientific principle(s) upon which a simple technology is based.	Given a technological device or process, the student will identify one or more scientific principles which form the basis of the device's functioning.
The student will be able to identify examples of the interdependence between science and technology.	Given a statement of a scientific principle, the student will identify a technological device or process which is based on it. Given an example of an appropriate technological device, the student will identify its use in scientific research.

II. THE NATURE OF TECHNOLOGY

The student will be able to identify the components of a functioning technological system including the input(s), processing, output(s), feedback, and control and comparison.	Given several diagrams, the student will identify that diagram which illustrates a functioning technological system.
The student will be able to describe the ways in which technological processes or devices are related to one another.	Given a technological process or device, the student will: a) Identify it as simple or complex.

	b) List other technological processes or devices (if any) involved in its manufacture or use. c) Describe how (or if) it has been influenced by past technological processes or devices.
The student will be able to explain how technology extends the abilities of human beings.	Given a list of technological devices, the student will explain how each can extend the abilities of a human being.
The student will be able to explain why a particular technological process or device became obsolete.	Given a particular technological device or process and a set of circumstances, the student will explain why it became obsolete.

III. THE INTERACTION OF SCIENCE, TECHNOLOGY, AND SOCIETY

The student will be able to demonstrate how science, technology, and society are interrelated.	Given a change in either technology, science, or society, the student will postulate probable changes in the other two areas.
The student will be able to demonstrate that technology has improved the standard of living.	The student will list three situations in which technology has improved his/her standard of living.
The student will be able to list examples of the impact of technology on jobs and careers.	The student will list three job and career opportunities that: a) Have been created by technological change in the past ten years. b) Have been modified by technological change in the past ten years. c) Have become obsolete due to technological change in the past ten years.
The student will be able to recognize that science and technology alone cannot solve society's problems.	The student will: a) Identify what he/she considers to be a serious problem within his/her community or school. b) Provide reasons why science and technology alone cannot solve the problem.
The student will be able to demonstrate that a technological process or device is developed in response to individual or social needs.	The student will list three technological processes or devices that benefit society and three which benefit individuals.
The student will be able to demonstrate that a technological process or device may not be accepted because of the attitude of society toward it.	Given a technological device or process not accepted by society, the student will identify the attitude that caused it not to be accepted.

The student will be able to report on the need for funds to support scientific research and the development of new technological processes or devices.	Given reference books and other research aids, the student will investigate and report on how public funds have supported a scientific or technological project, why that support was needed, and how the results have affected society.
The student will be able to identify advances in technological processes or devices that have resulted in nations interacting as a world community.	Given an appropriate example of nations interacting as a community, the student will identify the technological process or device which enabled that interaction.

IV. MAKING DECISIONS ABOUT TECHNOLOGY

The student will be able to describe probable long- and short-term consequences of a technological process or device.	The student will name a technological process or device and list one short-term and one long-term consequence, indicating whether each is a benefit or burden.
The student will be able to assess, and to accept or reject, a particular technological process or device based on its advantages and disadvantages.	Given a technological process or device, the student will: a) List at least two benefits and two burdens associated with it. b) Either accept or reject it based upon whether or not the trade-offs are acceptable to him/her. c) Explain the reason(s) why it was accepted or rejected.
The student will be able to demonstrate that there are often several possible solutions to complex technological issues.	Given a complex technological issue, the student will: a) Describe at least two possible solutions to the problem. b) Identify at least two disciplines from which experts may be expected to participate in the decisionmaking process.
The student will be able to cite examples in which legislation has been passed to regulate a technological process or device.	The student will name a government-regulated technological device or process and state how it is regulated.

PROCESSES

One of the major objectives in all science courses is the development of competence in processes used in science. The learning activities beginning on p. 27 in this publication will assist students in attaining this objective. Each activity is keyed to one or more of the processes listed below. For example, activity **(J-1)** involves processes **(1), (13),** and **(14)**.

(1) Observing objects and phenomena
(2) Describing observations
(3) Selecting suitable measuring instruments
(4) Developing skills in using laboratory equipment
(5) Measuring objects and phenomena
(6) Performing laboratory techniques
(7) Estimating measurements within limits of accuracy
(8) Recognizing a problem
(9) Formulating a working hypothesis
(10) Designing appropriate tests of a hypothesis
(11) Designing suitable procedures for experimental tests
(12) Processing experimental data
(13) Organizing data to show a functional relationship
(14) Interpreting observations and data
(15) Interpolating and extrapolating
(16) Evaluating a hypothesis in the light of data obtained
(17) Formulating generalizations based on relationships
(18) Recognizing the need for a theoretical model
(19) Formulating a theoretical model to accommodate knowledge
(20) Designing relationships satisfied by a model
(21) Deducing a hypothesis from a theoretical model
(22) Interpreting and evaluating tests of a model
(23) Producing a revised, refined, or extended model

CONCEPTS AND UNDERSTANDINGS —QUESTIONS AND ACTIVITIES

I. RELATIONSHIP OF SCIENCE AND TECHNOLOGY

Concepts and Understandings	Questions and Activities

A. Science and Technology Defined

1. Science and technology are human endeavors which affect all people.

What technological devices and processes do people use every day? **(J-1**, see also **Block I** for **I-36*)**

2. Science is the process of answering questions to gain an understanding of the natural world. It adds to and orders our knowledge of the natural world, and allows us to predict the outcome of events in the natural world.

Examples of science include:

- finding out how something "works"
- discovering how a firefly "lights"
- classifying organisms to help us understand how organisms are alike and different
- investigating the cause of acid rain
- developing the atomic theory to explain how matter behaves

How do people "do" science and technology? **(J-2, J-3, E-14, E-16, F-3, F-47, I-51, I-53)**

How is the Periodic Table of the Elements used in science and technology? **(H-47, 48, 51)**

How are minerals identified? **(D-3 through 11)**

How are organisms classified? **(A-20 through 22)**

Are the above technological processes?

3. Technology is the process of using resources, including scientific knowledge, to develop products and/or processes. When humans engage in technology, they attempt to solve the problems or meet the needs of the individual or society. An engineering rather than a science approach is used in technology.

Examples of technology include:

- the development of vaccines against polio and chicken pox
- the development of bionic limbs to give amputees greater mobility

Are the ways we use energy sources technological processes? **(I-1, 16, 17)**

What technological devices convert energy? **(G-13, I-13)**

How are machines examples of technology? **(G-14 through 19, I-14)**

What technological processes are involved in our uses of energy sources for fuel and other products? **(I-22 through 25, 30, 31, 33 through 35, 37 through 39)**

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* In addition to Block J activities, listed in this column are activities from other blocks which can be used as is or easily modified to provide instruction in science, technology, and society understandings.

- the installation of assembly lines to speed the manufacture of automobiles
- the development of a communication system to be placed in the helmets of football players
- the development of a new computer game

How are laboratory safety rules and techniques examples of technological processes? **(C-6 through 8, C-12, H-1 through 16)**

What technological processes are used in the chemical industry? **(H-31, 32, 38 through 41, 54, 64)**

How has technology influenced our food products? **(J-4, F-59)**

How are science and technology different? **(J-5)**

How does technology solve problems? **(J-6, F-47, I-50)**

How is a technological process or device developed? **(J-7)**

What do engineers and scientists do? **(J-8)**

The way in which cafeteria food is served to students at lunch is a technological process. How could you solve the problem of long cafeteria lines at lunch?

The way in which the buses line up to pick up students after school is a technological process. How could you improve this process?

B. Relationship of Science and Technology

1. Science and technology advance one another. Technological devices and processes are often invented or improved based on scientific principles. These new or improved processes or devices, in turn, can often be used to discover new scientific principles.

Examples of technological processes and devices used in scientific research include the:

- electron microscope
- telescope
- stopwatch
- nuclear reactor/accelerator

How are timing devices used by scientists in their research? **(J-9, G-12)**

2. Sometimes a technological process or device is invented without knowledge of the scientific principle behind it. The process or device then leads to the discovery of scientific principles.

Examples of these devices include:

- the steam engine
- sailing ships
- musical instruments
- early gliders and airplanes

3. The scientific principles on which technological processes or devices are based come from the life, physical, and earth sciences.*

Examples of technological devices or processes include:

- nuclear reactors
- steam engines
- eyeglasses
- airplanes
- elevators
- artificial organs
- topographic maps
- computers
- genetic engineering
- freeze-dried foods
- computer-derived weather forecasts
- robotic assembly lines
- satellite communication systems

What technological devices or processes are based on some common scientific principles? **(J-10)**

What technological processes and devices are used in chemistry? **(H-31, 32, 64)** In the study of weather? **(E-1 through 5, 13, 17, 18, 20)** In the study of oceans? **(D-21, 22)** In astronomy? **(F-26 through 28, 31)**

How is a thermometer made? **(G-54)** A spring scale? **(B-6)**

What is an electrophorus and for what was it used? **(G-74)**

What was an early battery like? **(G-86)**

How does a microscope aid in the study of organisms? **(A-23, 24)**

What are the scientific principles behind some common technological devices or processes? **(J-11)**

What scientific principle explains passive solar heating? **(I-62, I-63, E-38)**

What scientific principles explain the desalinization of sea water? **(I-61)**

How is a solar collector like a leaf? **(I-66)**

What scientific principles explain permanent magnets? **(G-60)** The electromagnet? **(G-61)** The compass? **(G-70)** The generator? **(G-88)**

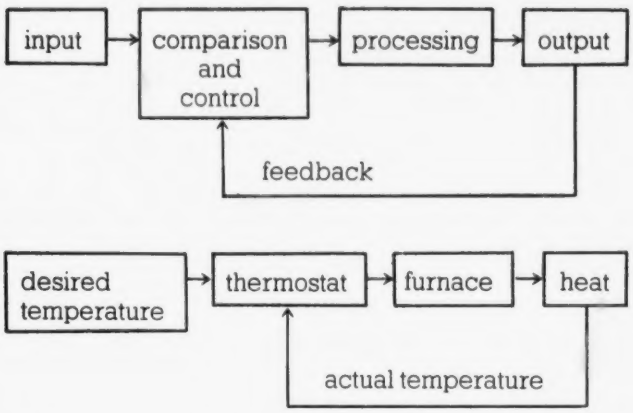
How are radioactive isotopes used in industry? **(G-99)**

* This concept should be reinforced for students as they receive instruction throughout science 7, 8, and 9. Teachers should make a special effort to show students how scientific principles from Blocks A through I are related to specific technological devices or processes.

II. THE NATURE OF TECHNOLOGY

A. Technology as a System

1. Some technological processes and devices can be viewed as systems which consist of input(s), processing, output(s), feedback, and comparison and control.



What components make up a technological system? **(J-12)**

How is a technological system like a biological system?

How is feedback used in biological systems? **(B-38)**

What can feedback tell us about machine wear? **(H-26)**

How are radioactive isotopes used as feedback? **(G-100)**

2. A complex technological process or device consists of simpler technological processes or devices working together as a system.

Examples include:

- a telephone network
- a digital clock
- an assembly line
- a computer
- a skyscraper, which could not exist without elevators

A thermostat is a simple technological process in what other more complex technological processes or devices? **(J-12)**

What machines are complex technological devices? **(G-21)**

How do technological processes or devices work together? **(J-13)**

How do technological processes that produce electrical energy work together as complex systems? **(I-37 through 39, 41)**

3. A technological process or device may require a complex system of other technological processes or devices for its manufacture, use, or maintenance.

For example, a microcomputer requires:

- a factory and assembly line for its manufacture
- an electrical system for its use
- diagnostic procedures and specific tools for its maintenance

What technological processes or devices are necessary for the preparation and serving of fast foods? **(J-14)**

What technological systems are necessary for flight in air? **(F-50, 51)** For flight in space? **(F-51, 61)**

B. Technology in Use

1. Everyone interacts with technological processes and devices in some way.

For example, a student may:

- wake to an alarm clock
- eat breakfast with a spoon
- ride a bus to school
- obey traffic lights at crosswalks
- understand that even subsistence hunters and gatherers used tools

Can the effects of technology be avoided? **(J-15, C-32)**

2. Technological processes and devices extend the abilities of human beings.

Examples include:

- communication systems
- work-saving appliances in the home
- space probes to other planets
- microscopes and telescopes
- eyeglasses and contact lenses
- calculators and computers
- radar and sonar
- artificial organs
- artificial intelligence

How can technological processes or devices extend human ability? **(J-16, I-17)**

How have technological devices extended our ability to listen to the human heart? **(J-17, B-73)**

How have technological processes and devices extended our ability to predict weather? **(E-1 through 5, 13)**

How do technological processes and devices help us to locate ourselves on Earth? **(D-25 through 31, F-15 through 19)**

What technological device allows us to detect radiation? **(G-96)**

What technological devices have allowed humans to achieve flight in air? **(F-42 through 49)** In space? **(F-44, 51, 57)**

3. Every technological process or device affects the environment in some way.

Examples include:

- the light bulb
- the automobile
- work-saving appliances
- a lawn mower
- a shovel
- strip mining
- road building
- waste water (sewage) treatment
- phosphate detergents

How do technological processes and devices modify the environment? **(J-18, G-31)**

How does the use of color affect people? **(G-41)**

What technological process provides us with safe drinking water? **(C-11)**

How does airport noise affect people? **(G-30)**

What technological device keeps our rivers and streams clean? **(A-39)**

How have our technological activities modified the environment so that fish hatcheries are needed? **(A-78)**

What technological device helps control the spread of forest fires? **(A-92)**

How do technological processes and devices affect the Earth's surface? **(D-1)** Plant life? **(A-72)**

4. A technological process or device often builds upon a past one.

Examples include:

- contact lenses, which developed from eyeglasses
- space flight, which developed from airplane and rocket flight

How does a technological process or device build on a past one? **(J-19, 20)**

How did the later space programs build on earlier ones? **(F-59)**

How has the stethoscope built on past technological devices? **(J-17, B-73)**

5. Sometimes a technological process or device becomes obsolete.

For example, obsolete technological devices include:

- water wheels for milling and grinding
- butter churns
- horse-drawn carriages
- steamships
- slide rules
- fountain pens

Why do some technological processes and devices become obsolete? **(J-21)**

Why are sundials obsolete? **(F-22)**

How have current laundering techniques rendered previous ones obsolete? **(J-22)**

6. Sometimes a technological process or device of the past is changed or improved so that it is used again.

For example, technological processes or devices which have been changed and are being used again include:

- windmills (wind turbines)
- airships or dirigibles
- passive solar housing

How have our energy sources and needs changed over time as new technological processes developed? **(I-18 through 20)**

Will wind power again become an energy source for us? **(I-68)**

Is a solar house in your future? **(I-62 through 65)**

7. Technological processes and devices are continuously being improved. When a technological process or device is improved, the cost of the process or device may be reduced.

For example, the cost has been reduced for:

- microprocessors
- hand-held calculators
- microcomputers
- grocery checkout stations, through the use of UPC symbols and laser scanners

What effect can an improved technological process or device have on the cost of products? **(J-23)**

Does increased efficiency improve a technological device? **(G-20, I-47, I-48, I-50)**

III. THE INTERACTION OF SCIENCE, TECHNOLOGY, AND SOCIETY

A. Nature of the Interaction

The interaction among science, technology, and society is continuous. Changes in one often affect the other two.

For example,

- The Industrial Revolution changed society greatly.
- Society affects the development of new technological processes and devices.
- Music videos have affected society.
- Scientific research in microelectronics has affected technology and society.
- A major electrical blackout has an immediate effect on society.

How do science, technology, and society affect one another? **(J-24)**

How have the examples given affected society, technology, or science?

B. Effects of Science and Technology on Society

1. Science and new technological processes and devices have caused major changes in the cultural, economic, political, and social systems of the world's societies.

For example,

- Selective plant and animal breeding and other modern farming practices have greatly increased food production and reduced the number of farmers in the United States.
- The United States is now moving from an industrial to an information society.
- Canals and railroads opened up the American West.
- Modern weather forecasting techniques directly affect social, recreational, and agricultural activities.

How are technological advances in medicine and nutrition related to science and society? **(J-25)**

2. Refinements and improvements in technological processes and devices have resulted in greater numbers and types of products to meet human needs. This greater availability of new products has improved the standards of living and has changed people's lifestyles.

How have science and technology changed our lifestyles? **(J-26)**

How has technology improved the standard of living? **(J-27, B-21)**

For example,

- American workers today work fewer hours per week and have more leisure time than in the 1800's.
- Our homes have many work-saving appliances.
- We are healthier and we live longer.
- Smallpox has been eradicated worldwide.
- Today, most households have fewer people. Also, people tend to live farther away from their relatives.
- Television has changed people's use of leisure time.

3. Science and technology affect business and industry.

a. When new technological processes and devices are introduced, practices currently used by business and industry may become obsolete.

For example,

- A computerized data management system may replace a traditional filing system.
- Conference telephone calls may replace group meetings.
- Letters may be sent electronically rather than mailed.
- Robots rather than humans may perform tasks on an assembly line or in hazardous places.

b. When new technological processes and devices are developed, new businesses and industries may be created while older ones become obsolete.

For example, new businesses and industries include:

- computer software manufacturers
- manufacturers of satellite television receivers (satellite dishes)
- health and exercise spas

For example, obsolete industries include:

- manufacturers of slide rules
- asbestos-products manufacturers
- the ice-cutting industry, which became obsolete when refrigerators were introduced

4. Science and technology affect career choices and employment.

How have science and technology changed business, industry, career choices, and employment? **(J-28)**

What new careers has the space program created? **(F-59)**

a. When new technological processes or devices are introduced in business and industry, jobs may be eliminated or modified and new jobs may be created.

For example,

- The use of robots on assembly lines can eliminate assembly-line jobs while creating robot-maintenance jobs.
- The use of the chain saw in forestry modified the logger's job.
- Direct long-distance telephone dialing eliminated some operators' jobs.
- The electronics industry has many new jobs.

b. Continuing education (life-long learning) and job retraining will be necessary to help people qualify for new jobs and adapt to modified jobs.

For example,

- Computers are replacing typewriters and standard ledgers.
- Medical technicians need continual retraining for new equipment such as nuclear magnetic resonance (NMR) scanners or computer axial tomography (CAT) scanners.

What qualifications are needed for available jobs and careers today? **(J-29)**

5. Although science and technology have contributed to many of society's problems, they have not contributed to all of them.

For example, science and technology are not responsible for natural disasters.

6. Science and technology alone cannot solve society's problems.

For example, science and technology alone cannot:

- eliminate hunger throughout the world
- ensure that nuclear war will never happen
- provide an environment with the least possible pollution
- control overpopulation

Why is it that the problem of world hunger cannot be solved by science and technology alone? **(J-30)**

C. Effects of Society on Science and Technology

1. A technological process or device is usually developed in response to a current or potential need, either of an individual or of society.

What kind of need is responded to when a technological process or device is developed? **(J-31)**

Examples include:

- vaccines against diseases such as measles
- chemo- and radiation therapy
- fast food restaurants
- fixing a machine with improvised parts
- developing a system to file manufacturers' coupons
- using a lunch box to carry a frog to school

2. Sometimes a technological product is developed first, and the need for the product created later through marketing.

How does advertising create a need for a product? **(I-45)**

How are color and light used in marketing? **(G-42, 45)**

3. Use of a technological process or device may depend on the attitudes of individuals or societies toward it.

For example, to what extent have the following been accepted?

- food products such as chicken hot dogs, turkey cold cuts, or tofu
- the recumbent bicycle or the mountain bicycle
- front-wheel drive automobiles
- nuclear energy
- the supersonic transport (SST)

Would you eat irradiated food? **(J-32, G-94)**

Would you drink warm milk? **(J-33, B-7)**

Will no-till planting be accepted as a farming practice? **(J-34, D-42, A-85)**

Have we accepted unit pricing and generic products at the grocery store? **(J-35)**

Why are some inventions not accepted by society? **(J-36)**

4. Some societies can afford to and do provide funds to support scientific research and technological development.

For example, the Federal and state governments provide public funds for:

- space exploration
- medical research
- energy research
- weapons and other defense research
- geological and biological surveys

Also, foundations and business and industry privately fund scientific research and technological development in areas of interest to them.

D. Global Effects of Technology

1. The development or use of a technological process or device by one country may have an international or global impact.

How does technology impact globally? **(J-37, E-13)**

For example,

- Acid rain extends beyond national boundaries.
- Adoption of advanced technological processes in Japan affects industry in the United States.
- Increased carbon dioxide emissions in industrialized countries may produce a global greenhouse effect.
- Various food and mineral resources are transported worldwide.
- An international telephone system allows people to talk to one another across national boundaries.
- Satellite television transmission allows people to see events in other countries almost as they happen.
- The threat of nuclear war affects all nations.

2. As a result of advances in technological processes and devices, nations and individuals interact more and more as a world community.

For example,

- Worldwide communication systems allow us to react quickly to such crises as famine or earthquakes.
- The United States now has a daily newspaper with national circulation.

How does technology affect relationships among nations? **(J-38)**

How often do we eat foods from other countries? **(J-39)**

IV. MAKING DECISIONS ABOUT TECHNOLOGY

A. Technology and Choice

Technological processes and devices offer people increased choices.

For example, we have increased choices in:

- foods
- entertainment and use of leisure time
- transportation
- careers

How frequently are choices made among technological processes and devices? **(J-40)**

How have our choices in use of leisure time changed? **(J-41)**

What choices do we have in processed foods? **(J-42)**

On what basis do people choose among different technological devices that perform the same task? **(J-43, I-40, I-57, I-58)**

B. Assessing Technology

1. The purpose for which a technological process or device is developed and how people decide to use the process or device will determine its effect on individuals or society.

Is a technological process or device good or bad? **(J-44)**

Examples include:

- nuclear and chemical weapons
- nuclear reactors
- X-rays
- electronic surveillance
- drugs
- microcomputers
- video games and arcades
- a knife

2. Every technological process or device has advantages and disadvantages associated with its use, providing benefits and burdens for people and the environment.

Examples include:

- radiation treatments and chemotherapy
- nuclear energy
- pesticides and herbicides
- food preservatives

What are the advantages of the automobile? Of electricity? What are some of the disadvantages? **(J-45, A-78, E-32, E-33)**

What are the advantages and disadvantages of recycling materials? Of not recycling them? **(I-52, 67)**

What are the advantages and disadvantages of different methods of storing radioactive waste? **(I-35)**

3. A particular technological process or device should be assessed by its advantages and disadvantages.

How should technological processes and devices be assessed? **(J-46)**

What governmental agencies are responsible for assessing a technological process or device?

4. When a technological device or process is adopted, information should be collected continuously on the short- and long-term benefits for people and the environment, and on the potential adverse consequences for present and future generations and the environment.

For example, information is accumulating on the impact of:

- herbicides sprayed along roadsides and under power lines
- nuclear energy
- diagnostic radiation
- chemotherapy
- various vaccines and medications
- food preservatives and colorings

Will we be sorry tomorrow for the technological processes and devices we use today? **(J-47)**

What are the benefits of the technology of reforestation? **(A-93)** Of wildlife conservation? **(A-94)**

C. Technology and Decisionmaking

1. Decisions about a technological process or device should be based on consideration of its short- and long-term consequences. Often, people choose short-term benefits without paying attention to long-term burdens.

Examples include:

- general use of broad-spectrum herbicides and pesticides on crops
- use of fossil fuels for energy
- cigarette smoking

Sometimes, the short-term benefits override the long-term burdens.

Examples include:

- use of narcotics for reducing pain
- use of a selective pesticide to combat a severe pest infestation (gypsy moth, Mediterranean fruit fly)

Sometimes, the long-term benefits override the short-term burdens.

Examples include:

- use of returnable bottles
- use of seat belts
- not using a pesticide for a mild pest infestation

2. A technological process or device may be short-lived or terminated when the disadvantages outweigh the advantages or when a more advantageous technological process or device is developed. Sometimes a technological process or device can be modified to reduce or eliminate its disadvantages.

Examples include:

- DDT, which has been banned from use in the United States
- sailing ships, which were replaced by engine-powered ships
- thalidomide, an anti-nausea drug which caused birth defects
- nonreturnable bottles, which have been prohibited by law in many states
- the United States steel industry, which must be modernized before it can compete successfully with the Japanese steel industry

How do we overcome one disadvantage of electricity — its potential to injure? **(G-92, 93)**

How have aerosol sprays been modified to overcome their disadvantages? **(J-48, E-32)**

3. A decision about a technological process or device leads to other decisions which have to be made.

For example, choosing a crop to plant leads to decisions about:

- tilling methods
- planting pattern
- choice of fertilizers and insecticides
- harvesting method
- equipment to be used/purchased
- storage arrangements

For example, choosing to build a new road for transportation leads to decisions about:

- the route
- the road surface
- bridge locations
- access and exit points

How does making a decision about a technological process or device lead to other decisions? **(J-49)**

4. Use or nonuse of a technological process or device may lead to serious moral, ethical, constitutional, or legal questions and issues.

Examples include:

- use of animals for medical research
- nuclear weapons testing
- use or nonuse of life-support systems with the terminally ill
- use of fossil fuels, which results in acid rain

How do we decide who receives an organ transplant? **(J-50)**

What are the moral, ethical, constitutional, and legal questions arising from the use of life-support systems? **(J-51)**

Who "owns" the Sun? **(J-52, I-60)**

5. Since a complex technological issue has several possible solutions or alternative courses of action, decisionmaking about an issue usually involves trade-offs (compromise) among the alternative courses of action. Trade-offs are often made between the benefits and burdens for people and the environment. Some burdens are accepted because the benefits outweigh them.

Examples include:

- vaccines, such as for whooping cough, which may cause serious side effects in a few children
- electricity as a preferred secondary energy source
- the automobile as a primary means of transportation

Why has energy become a serious technological issue? **(I-43, 44)**

How do we make decisions about technological processes or devices? **(J-53)**

What are the trade-offs between strip and underground mining? **(I-29)**

What trade-offs would we make if we conserved energy by using the family automobile less? **(I-46)**

What issues are associated with the use of nuclear energy? **(G-101)**

6. To resolve a complex technological issue, experts from many disciplines (e.g., science, political science, sociology, philosophy) may have to contribute information that aids in the decisionmaking process.

For example,

- Decisionmaking about toxic waste disposal requires information about demographics, disposal techniques, politically acceptable alternatives, and environmental impact.
- Decisionmaking about genetic engineering requires information about environmental impact, ethics, safety precautions, and risks to health.

7. Experts often disagree about solutions to complex technological issues.

Examples include:

- genetic engineering
- nuclear energy
- toxic waste disposal

8. Because people hold different values, the resolution of a technological issue may not be acceptable to every person or group.

D. The Role of Government in Decisionmaking

1. Sometimes governments pass laws to regulate, control, or ensure use of a technological process or device for the benefit of society or the protection of individuals.

Examples include:

- the seat belt law
- the bottle bill
- motorcycle helmet laws
- car emission standards
- handgun laws
- restrictions on the use of Citizen's Band radios
- regulation of wiretapping and other kinds of electronic surveillance
- laws protecting the privacy of computer data bank information
- nuclear power plant licensing procedures

What information do we need in order to use natural resources wisely? **(D-14, 24)**

How has government become involved in the use of seat belts? **(J-54,G-8)**

What technological processes and devices does the government regulate? **(J-55)**

What is the role of the lobbyist in the political process?

What role do environmental organizations, such as the Sierra Club, play in the political process?

2. Public funding for science and technology is just one priority of society. Decisions about funding science and technology projects are made by society through the political process.

For example, Federal funds are used for:

- demographics research
- space programs
- agricultural research
- disease tracking

How are funds provided for science and technology? **(J-56)**

Should we fund space programs? **(F-62)**

Should we fund research in nuclear fusion? **(G-102)**

3. Society, through government, has the responsibility to ensure the quality of life for our own and succeeding generations. Society should use science, technology, and social action as needed to maintain the health of our environment, to use our natural resources wisely, and to provide acceptable living conditions for everyone.

Examples include:

- conservation of mineral resources
- preservation of wilderness
- preservation of prime agricultural land
- ensuring pure waters and clean air
- protection from toxic wastes
- prevention of soil erosion
- prevention of desertification in sub-Sahara Africa and tropical rain forests
- protection of fragile ecosystems and endangered species
- provision of adequate food, housing, and health care for all

What might be the result of large-scale cutting of the rain forests? **(E-48)**

How can we protect the water table? **(D-40)**

Why is it important to protect ecosystems? **(A-74)**

How can we prevent soil erosion? **(A-84, 85)**

How can we enrich our soil? **(A-86)**

APPENDIX A —LEARNING ACTIVITIES

J-1. HOW DOES TECHNOLOGY AFFECT OUR EVERYDAY LIVES?

(1, 13, 14)

PURPOSE:

To realize how technology affects us.

PROCEDURE:

(1) Make a list of the products of technology that you encounter:

- on the way to school in the morning
- during the school day
- during after-school activities
- at home in the evening

(2) Classify your products according to human needs such as:

- water
- food
- shelter
- transportation
- communication
- health
- recreation

RESULTS:

A typical list of grouped products might look like the following.

Group	Products
water	running water (especially hot water for bathing)
food	frozen and canned foods, snacks, milk and ice cream, fresh vegetables, toaster, stove, refrigerator, microwave oven
shelter	furnace, house, electric blanket
transportation	cars, buses, subways, trains, roads, traffic lights
communication	radio, books, television, pens and pencils, paper, telephone, movies, microcomputer
health	toothbrush, vitamins
recreation	sports equipment, stereo system, games

J-2. HOW DO WE "DO" SCIENCE AND TECHNOLOGY?

(8, 9, 10, 11)

PURPOSE:

To illustrate how people do science and technology.

INTRODUCTION:

What happens to fresh foods and vegetables when they are cut open and exposed to the air? You have probably observed what happens many times. But did you know that, for at least one person, these observations led to a very important discovery, part of which you can replicate in a scientific way?

MATERIALS:

fresh fruits and vegetables

ADVANCE PREPARATION:

Make sure that lemons are included in the fruits to be tested. A supply of lemon juice is recommended for Part B.

PROCEDURE:

Part A

(1) Ask a question from the information above whose answer you want to discover by actually testing fruits and vegetables.

(2) Plan how you will go about answering this question. Your planning should include:

- the foods you will test
- how you will test them
- how you will report your results

(3) Carry out your investigation and report your results.

Part B

(4) Is there a way to prevent some fruits and vegetables from browning? Look over your results and see if you can formulate a hypothesis to answer this question.

(5) Plan how you will test your hypothesis, then carry out the investigation. Include a control.

(6) How can you prevent fruits and vegetables from browning?

(7) Do research to find out (or ask your teacher to tell you) what important scientific discovery the observation of food browning led to.

RESULTS:

From careful observation, discrepancies arise that the observer may wish to resolve. In this activity, the discrepancy is that some foods brown on exposure to air, while others do not (Part A). What prevents some foods from browning? (Part B) The answer to this question once led to an important scientific discovery.

TEACHER BACKGROUND:

This activity is intended as an activity in which students state the questions and then seek, through problem-solving, to answer the questions themselves.

THE SCIENTIFIC DISCOVERY:

Vitamin C (ascorbic acid) was discovered by Dr. Albert Szent-Gyorgyi. He won the Nobel Prize for this and other biochemical work. Dr. Szent-Gyorgyi has described his work on vitamin C as originating from curiosity about a common observation: the browning of bananas when exposed to the air. This observation raised the question (a discrepancy) of why bananas (and apples and potatoes) turn brown, while other foods, such as citrus fruits, green peppers, and tomatoes, do not.

Dr. Szent-Gyorgyi formulated a hypothesis: foods that do not turn brown when exposed to air contain an "antibrowning substance." This is consistent with the observation that lemon juice prevents browning of apples. Dr. Szent-Gyorgyi set out to isolate this antibrowning substance. He found that it was identical to what was already known as vitamin C (the anti-scurvy vitamin) and he determined the structure of the molecule. As a result, vitamin C is now manufactured and sold as a diet supplement.

J-3. DO ALL ORANGE JUICES CONTAIN THE SAME AMOUNTS OF VITAMIN C?

(This activity is an extension of **Activity A-49** in **Block A, Living Systems: Organisms**.)

(6, 13, 14)

PURPOSE:

To illustrate how science answers questions about the natural world.

MATERIALS:

three medicine droppers
various kinds of orange juice: fresh, frozen, canned, dehydrated
a stirring rod or applicator stick
starch indicator
beakers or wide-mouthed jars
dilute hydrochloric acid
safety glasses

ADVANCE PREPARATION:

To make the iodine solution, dissolve 60 grams of potassium iodide in 50 ml of ethanol. Put the contents in a 1-liter beaker, and add 950 ml of distilled water to make 1 liter of solution.

To make the starch indicator, dissolve 1 tablespoon soluble starch (such as potato or corn starch) in 1 liter of distilled water.

If necessary, prepare the various orange juices according to directions.

PROCEDURE:

(1) Choose one juice to be sampled and measure 50 ml of it into a beaker.

Caution: Wear your safety glasses until you have completed (8) for each sample of orange juice.

(2) Use a medicine dropper to add 2 *drops* of dilute hydrochloric acid to the sample and mix thoroughly.

(3) Select a clean medicine dropper and add two medicine droppers full of starch indicator to the orange juice and mix.

(4) Fill a clean medicine dropper with the iodine solution. Add the iodine solution to the orange juice, *one drop at a time*, mixing after each drop. Count how many drops are used. Keep adding and mixing until a purple color persists.

(5) Record how many drops of iodine solution were needed to reach this point.

(6) Rinse your medicine droppers in distilled water. Run a second sample of the same juice through the same steps as a check on accuracy. If the second sample varies substantially from the first, run a third sample. If you run three samples, average the three results as your final figure.

(7) Repeat (1)-(7) on the different kinds of orange juice.

(8) Design a control for this experiment. Test distilled water instead of orange juice.

(9) Construct a bar graph of your results. Place the kinds of orange juice on the x-axis and the number of drops of iodine on the y-axis. The number of drops of iodine needed to produce a persistent purple color indicates the relative vitamin C content of each orange juice. The more iodine needed to change the color of the juice, the greater the vitamin C content.

(10) Which orange juice had the largest concentration of vitamin C? The least? Can you formulate any hypotheses as to why one juice had more than another?

(11) Answer the following questions.

(a) Why did you repeat the procedure at least twice for each type of orange juice tested? Do scientists test each other's results?

(b) Are the results the same for each group performing the experiment? If not, what might have caused results to be different?

(c) Why are controls necessary in a scientific investigation?

(d) How do your experimental results compare with the relative amounts of vitamin C in the juices as stated on the containers?

RESULTS:

The procedure in this activity is based on the reaction between vitamin C and iodine. This reaction prevents the iodine from affecting the starch until the vitamin C is used up. In the human body, nicotine is a substance that affects vitamin C levels. The different kinds of orange juice will have different concentrations of vitamin C.

J-4. WHAT IS A "SPACE PICNIC"?

(This activity is an extension of **Activity F-59** in **Block F, Astronomy and Aerospace Science**.)

(1, 2, 11, 14)

PURPOSE:

To illustrate how technology has affected our food products.

MATERIALS:

freeze-dried, fresh, and canned or frozen samples of the same foods

PROCEDURE:

(1) Check grocery store shelves and outdoor recreation catalogs for products now available to consumers because of technology developed through the space program. One example is the product known as Tang which was originally developed for the space program.

(2) Working in small groups, plan a "space picnic" using the products discovered in (1).

(3) Do these "space" foods taste as good as our "old" foods? Prepare a blind taste test to compare a reconstituted freeze-dried food with the "original" product.

(a) Reconstitute a freeze-dried food.

(b) Prepare samples of the fresh or canned or frozen food. Label each sample only A or B, so that the taster does not know which sample it is.

(c) Taste and compare the products. Record the results.

(4) Are these "space" foods as nutritious as our "old" foods? Compare labels and nutrition charts and record the results.

(5) How do these "space" foods compare in price with our "old" foods? Compare price per gram or ounce and record the results.

(6) Answer the following questions.

(a) Which product did you prefer for taste? For nutrition? For cost? Why?

(b) Why are freeze-dried foods used on space flights? On extended wilderness trips on Earth?

RESULTS:

Freeze-dried foods were first developed for space travel. The food is frozen in a vacuum. Foods usually available on grocery store shelves include powdered fruit drinks and various kinds of freeze-dried food. Outdoor recreation specialty stores will have a wide variety of freeze-dried foods including eggs, fruits, and even ice cream.

Students' preferences on the taste test will be influenced by many factors including the type of product usually consumed.

J-5. HOW ARE SCIENCE AND TECHNOLOGY DIFFERENT?

(1, 2, 14)

PURPOSE:

To distinguish between science and technology.

MATERIALS:

pictures and/or descriptions of people engaged in science or technology

Suggested pairs of pictures showing science versus technology include:

Science	Technology
Galileo observing motion of objects rolling down inclined plane	Young person coasting down hill in soap box racer
Chemist heating test tube over Bunsen burner	Cook using a stove to heat food

Microbiologist looking through microscope

Doctor or nurse immunizing patient(s) against disease

PROCEDURE:

(1) Show pictures or read descriptions to students. Are the people pictured or described engaged in science or technology? Use student responses to discuss the relationship and difference between science and technology.

Note: If the pictures are merely sorted between science and technology at this point, they can be used again in **Activity J-10** to relate scientific concept and technological application.

(2) Ask students to collect pictures or write descriptions of people engaged in science or technology and share them with the class.

J-6. CAN I MAKE A BETTER PAPER AIRPLANE?

(This activity is an extension of **Activity I-50** in **Block I, Energy: Sources and Issues** and **Activity F-14** in **Block F, Astronomy and Aerospace Science**.) **(8, 11, 12, 14)**

PURPOSE:

To use problem-solving in the area of technology.

MATERIALS:

paper
reference books
safety glasses

PROCEDURE:

(1) Working in groups of three to four, use problem-solving to design and produce paper airplanes.

(a) *Identify the need or problem*

What is the problem you want to solve or need you want to meet? Examples might include: Is there an accurate way to get waste paper into a waste basket? How can we make a device that will stay in the air the longest? What device will fly the longest distance?

(b) *Develop a plan or idea*

Discuss ways to solve your problem. For example, getting paper to a waste basket by folding it into a shape like an airplane is a possible idea.

(c) *Research the plan or idea*

What additional information do you need? For example, what type of paper is best, or what plans have others developed?

(d) *Develop a design*

Based on the principles of flight, design an airplane to solve your problem or meet your need.

(e) *Build a prototype*

Build the airplane from your design.

(f) *Test the prototype*

Decide what tests you will use on your prototype. Carry out the tests and keep accurate records. For example, how many times did the airplane go into the waste basket?

(g) *Evaluate the prototype*

How well did the prototype perform? For example, did it consistently hit the waste basket? Can its performance be improved by redesign? If so, redesign it.

(h) *Acceptance and production*

If the prototype is accepted (with or without redesign) it is then ready for production. If the prototype is rejected, you may wish to go back and start again at (b).

(2) Answer the following questions.

(a) When problem-solving is used in industry and business, who identifies the need or problem? Who evaluates the product?

(b) Are consumers ever involved in need identification? In evaluation?

Note: At the end of this activity, an airplane-flying contest can be held for each problem students worked on. The contest can be likened to market competition, with winning planes examined for their design superiority.

J-7. HOW IS A TECHNOLOGICAL PRODUCT DEVELOPED?

(13, 14, 17)

PURPOSE:

To illustrate that, as a technological product is developed, several fairly uniform steps are followed.

MATERIALS:

library reference books and magazines

PROCEDURE:

(1) Divide the class into groups of three students each. Ask each group to choose one of the following technological products:

- airplane
- automobile
- camera
- polio vaccine
- radio
- television
- telephone
- light bulb
- microcomputer
- phonograph

(2) Using library resources, have each group research the development of its chosen product and answer the following questions.

(a) What need was the product designed to fulfill?

(b) How did the idea for the product first come into the mind of the inventor(s)?

(c) What kind of research was done before the product was developed?

(d) What were the main features of the product's design?

(e) Describe the prototype or initial form of the product that was constructed.

(f) How was the prototype tested?

(g) In what ways was the prototype modified before the product was mass produced?

(3) Ask each group to report on its findings to the full class and respond to other students' questions.

RESULTS:

Students should realize that most technological products are developed using methods that are quite fundamental to problem-solving.

J-8. WHAT DO ENGINEERS AND SCIENTISTS DO?

(1, 14, 17)

PURPOSE:

To provide concrete examples of how an engineer and a scientist solve problems.

PROCEDURE:

(1) Invite one or two engineers to speak to the class about the work they do. It is helpful if the engineers are working on a project that is of interest to students such as a new product students might use. (An engineer can be located through local industry or a student's parent may be an engineer. You may wish to find a woman engineer, too.)

(2) Provide the engineers with information on what the class is studying, including the problem-solving model. Remind the engineers of the students' grade level, and ask them to use a problem they are working on to illustrate the problem-solving model. Encourage the engineers to bring with them some physical repre-

sentations of the problem such as the design and the prototype.

(3) Several days before the class visit, ask students to draw up a list of questions they would like to ask the engineers. Appoint one or two students to act as hosts/hostesses and to introduce the guest speakers.

(4) Repeat (1)-(3) by inviting one or two scientists to speak to the class about how they use problem-solving.

(5) Discuss the similarities and differences between engineers and scientists. Are their work roles totally separate? Is there overlap between what they do?

J-9. WHICH TIMING DEVICE WOULD YOU CHOOSE FOR A SCIENTIFIC INVESTIGATION?

(This activity is an extension of **Activity G-12** in **Block G, Energy & Motion**.) **(3, 5, 7, 14)**

PURPOSE:

To illustrate that some technological devices can be used in scientific research.

MATERIALS:

one meter of string

masses

various timing devices: quartz or spring-wound analog watches, with and without second hands; digital watches; analog and digital stop watches

PROCEDURE:

(1) Set up a pendulum by suspending a mass from the string. Attach the string to a support from which the pendulum can swing freely.

(2) Start the pendulum swinging. *Each time you start the pendulum, make sure you start it at the same point in space (or the same distance from its nonswinging position).*

(3) Observe the pendulum.

(4) Plan how you would carry out an investigation to determine the most precise timing device. Be sure to plan what data you're going to collect and how you're going to collect them. (Hint: To find the time required for one swing of the pendulum, you might want to time 10 swings and find the average by dividing by 10.)

(5) Record your results and compare them with the rest of the class.

(6) Answer the following questions.

(a) What is the smallest unit of time you can measure with each device?

(b) Which device is most precise?

(c) How can more precise timing devices aid scientists?

RESULTS:

The more modern the timing device, the smaller the unit of time it can usually measure. The smaller the unit of time which can be measured, the greater the precision. Originally important for navigation, precise time measurements are now needed to investigate systems that are very small (nuclei of atoms and fundamental particles in nature) and very large (astronomical systems).

J-10. CAN SCIENCE AND TECHNOLOGY BE MATCHED?

(17, 1)

PURPOSE:

To identify a technological device or process based on a given scientific concept.

PROCEDURE:

(1) Call out a scientific concept and ask students to think of a technological device or process which derives from it.

(2) From **Activity J-5**, have students match the pictures and descriptions illustrating scientific concepts with their respective technological applications.

RESULTS:

laws of motion	space travel
electricity	electrical appliances
electromagnetic waves	radio and TV
chemistry (chemical bonds)	synthetic materials
radioactivity	nuclear medicine
nuclear fission	nuclear reactors
structure of matter	microelectronics

J-11. WHAT IS THE SCIENTIFIC BASIS FOR TECHNOLOGY?

(17)

PURPOSE:

To identify the scientific concepts associated with a list of technological devices or processes.

PROCEDURE:

Consider your list of the products of technology from **Activity J-1** or the list below. Indicate upon what scientific concept the technological devices or processes are based.

Device or Process

(1) Pasteurization
(2) Ball bearing
(3) Barometer
(4) Thermometer
(5) Thermostat
(6) Microwave oven
(7) Electric meter
(8) Microscope
(9) Telescope
(10) Centrifuge
(11) Quartz watch
(12) Metric balance
(13) Solar cell
(14) Generator
(15) Christmas tree lights
(16) Rocket
(17) Gyroscope
(18) Gun or cannon
(19) Glider
(20) Hot air balloon
(21) Blimp

RESULTS:

Scientific concepts from the list above are provided below. Other lists can easily be made from the specific subject (life, earth, or physical science) students are currently studying.

(1) Heat kills bacteria.

(2) By reducing area of surface contact, angular motion reduces friction.

(3) The pressure of columns of different static fluids at the same level must be the same.

(4) Most substances expand when heated.

(5) Different substances expand by different amounts when heated.

(6) Microwave energy is readily absorbed by water molecules.

(7) Magnets exert a force on electric currents.

(8) Lenses refract light to focus images.

(9) Lenses refract light to focus images.

(10) Artificial gravity is produced by the acceleration of a reference frame; this is also known as "centrifugal force."

(11) Molecules and crystals are characterized by natural frequencies of oscillation.

(12) A system is in equilibrium when both the net force and net torque exerted on it are zero.

(13) Electrons in solids can be excited to higher energy levels when they absorb light.

(14) Current is generated in a coil subject to changing magnetic flux through it.

(15) If enough heat is generated by passing electric current through a filament, light is given off.

(16) When an object exerts a rearward force on its environment, it is propelled forward — Newton's Third Law.

(17) Conservation of angular momentum.

(18) When an object exerts a rearward force on its environment, it is propelled forward -- Newton's Third Law.

(19) Bernoulli's principle.

(20) Archimedes' principle.

(21) Archimedes' principle

J-12. WHAT IS A TECHNOLOGICAL SYSTEM?

(1, 2, 14, 17)

PURPOSE:

To distinguish among the components of a technological system.

MATERIALS:

bimetallic strip
simple electric circuit
light bulb
heat source
reference materials

PROCEDURE:

(1) Demonstrate what happens to a bimetallic strip when it is heated.

(2) Connect the bimetallic strip into an electric circuit containing a light bulb. Using the electric circuit as an analogy, ask students how the bimetallic strip regulates temperature when used in a thermostat.

(3) How do a thermostat and furnace comprise a technological system? Use a diagram to show how their relationship can be represented in terms of input, processing, output, feedback, and comparison and control.

(4) Ask students to use reference materials and to survey the appliances in their homes to determine what other technological systems have thermostats.

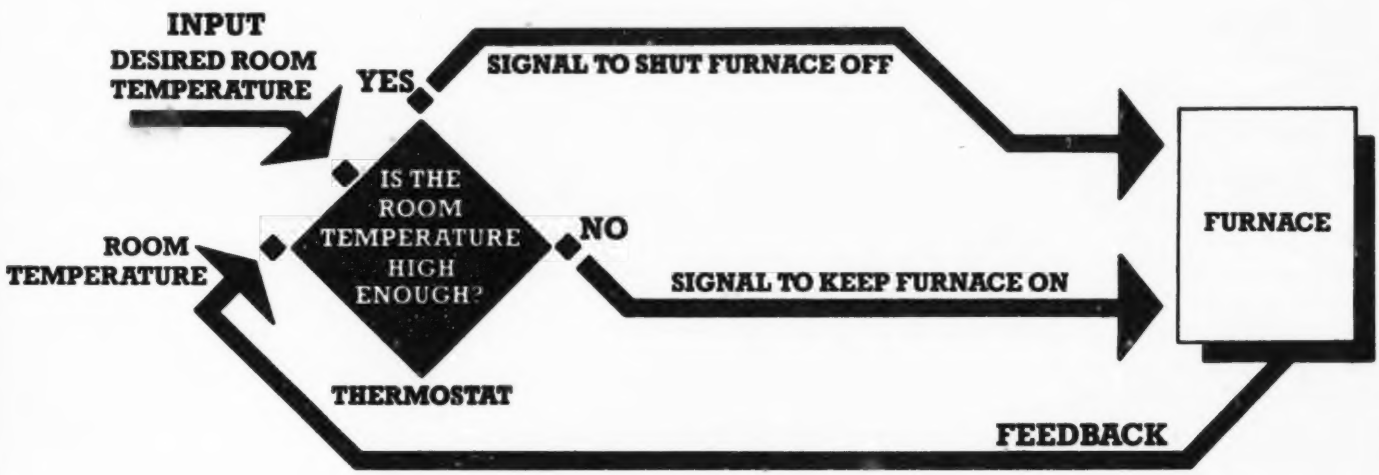
Caution: When surveying appliances, *do not* take them apart. Simply analyze how they work to determine if a thermostat is involved.

(5) Ask students to consider an automobile and its driver as a system. What are the input(s), processes, output(s), and feedback associated with each of the following parts of the system: carburetor, engine, pistons, and driver?

RESULTS:

A bimetallic strip works in the following way: when heated, it bends and opens the circuit; and the furnace shuts off. Upon cooling, it straightens out and closes the circuit, and the furnace turns on.

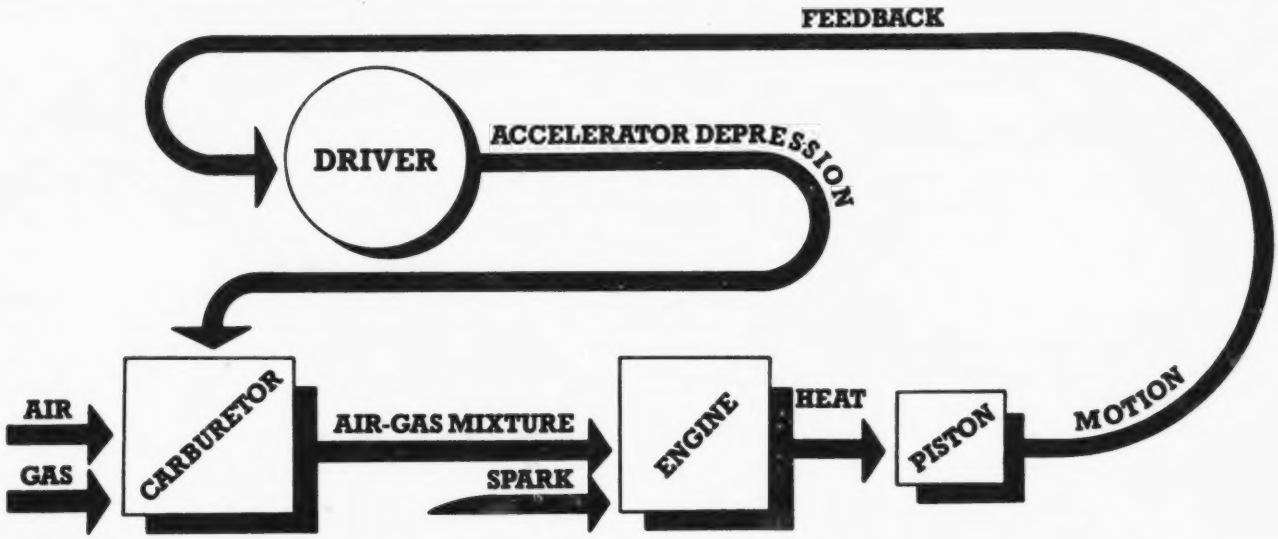
A typical student diagram of the thermostat-furnace system might look like this:



If students are familiar with flow charts, they can draw a flow chart to illustrate the thermostat-furnace system.

The components of the driver-automobile system are shown in the table and diagram below.

Part	Input	Process	Output	Feedback
carburetor	air & gas	mix air & gas	air-gas mixture	motion of car
engine	air-gas mixture & spark	combustion	heated gas	—
pistons	heated gas	response to heated gas	motion	—
driver	motion of car	decide on changes in speed	accelerator depression	car speeds up



J-13. HOW DO TECHNOLOGICAL PROCESSES AND DEVICES WORK TOGETHER?

(17)

PURPOSE:

To distinguish between simple and complex technological processes and devices.

PROCEDURE:

(1) Review with the class the technological examples from the following activities:

(a) **Activity J-12.**
The thermostat is a simple technological device to regulate temperature. Combined with a furnace (another simple device) and heating ducts, it forms a regulated heating system for a building (a complex technological device).

(b) The lists developed in **Activities J-1** and **J-11**.

(2) Ask the class whether a given example is a simple or complex technological process or device.

(3) Have the class work in small groups to develop other examples of simple and complex technological processes and devices.

RESULTS:

Because the items listed in **Activity J-11** are based mostly on a single scientific concept, students are likely to regard them as simple technological processes or devices. However, to the extent that the items rely on auxiliary processes or devices, they may be regarded as complex. Lack of clarity on this distinction can be a useful basis for class discussion.

Some of the items listed in **Activity J-1** may be more obviously complex such as processed food, synthetic fabrics, modes of transportation, and machines to dispense lunch.

J-14. WHAT IS IN A "BIG BURGER"?

(1, 12, 17)

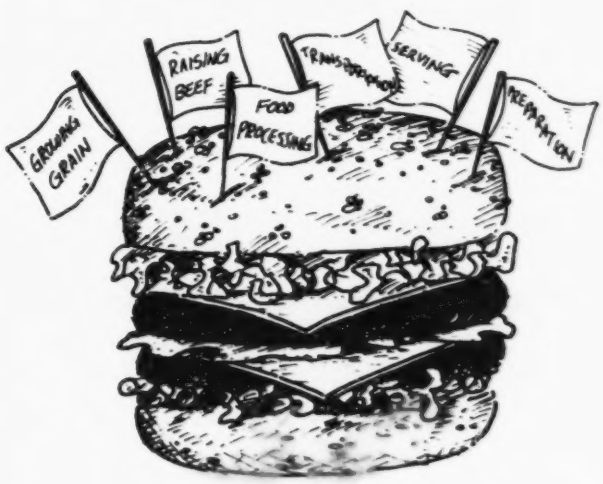
PURPOSE:

To realize that a particular technological product may depend on a complex system of other technological processes and devices.

MATERIALS:

one "Big Burger" for demonstration or one "Big Burger" for each pair of students to share when the activity is finished (optional)

reference books and magazines



PROCEDURE:

(1) Look at the "Big Burger." From what foods is it made? List these foods in the first column of the data table provided.

(2) Complete the data table by listing the technologies used in getting each food into the "Big Burger." Remember that technologies are used in growing, processing, and transporting the foods and in preparing and serving the product. Start with the growing of each food and follow through to the mouth-watering experience of eating the "Big Burger." Use reference materials if necessary. Some examples of the technologies include:

- *Growing*: using a tractor to plant the wheat seeds
- *Processing*: rolling the wheat into flour
- *Transporting*: using a truck to transport the foods to the restaurant
- *Preparing*: using a plunger dispenser to put the ketchup on the "Big Burger"
- *Serving*: putting the "Big Burger" in a container

Data Table

	Technologies Used In				
Food	**Growing**	**Processing**	**Transporting**	**Preparing**	**Serving**

RESULTS:

The completed data table should show that even a seemingly simple activity as preparing a "fast food" can be the result of many technologies linked together.

Adapted from "How is Energy Used in Our Foods?," *Energy and Safety: Science Activities for Elementary Students*,© 1984 by the Research Foundation of SUNY on behalf of the New York Energy Education Project. Used with permission.

J-15. CAN WE ESCAPE AIR POLLUTION?

(This activity is an extension of **Activity C-32** in **Block C, Living Organisms: Microorganisms**.) **(1, 2, 14, 17)**

PURPOSE:

To illustrate that, by polluting the air we breathe, some technological processes affect everyone.

INTRODUCTION:

Smog is a word coined in 1905 to describe a mixture of smoke and fog. Smog is now considered to be a mixture of air pollution and fog. Air pollution may result from smelting; from burning coal, oil, or wood; from automobile exhaust; or from natural particles in the air.

While smog forms in areas that are heavily industrialized (like cities), air pollution without smog is far more widespread.

MATERIALS:

a jar with a screw top
a block of wood
nails
masking tape or petroleum jelly

PROCEDURE:

(1) Remove the top from the jar.

(2) Nail the top, inside up, to a block of wood.

(3) Wrap the masking tape around the jar, sticky side exposed to the air, or cover the jar with petroleum jelly.

(4) Screw the jar onto its top.

(5) Place the jar outside above ground level.

(6) Label the compass points correctly on the jar: N (north), S (south), E (east), and W (west).

(7) Observe the jar daily and record your observations in a data table. At the end of a week, remove the jar.

(8) Answer the following questions.

(a) At the end of the week, which compass direction on the jar showed the greatest change?

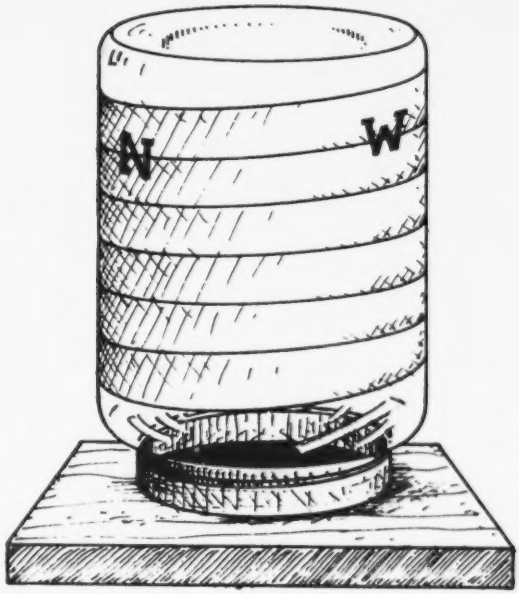
(b) From what direction, if any, did most of the pollution arrive?

(c) Can you determine local causes for the pollution? If so, what are they?

(d) How do particles in the air contribute to air pollution?

(e) How is your body protected against particles in the air you breathe?

(f) What measures have been taken to reduce the amount of air pollution caused by technological processes?



RESULTS:

In every location where a jar is placed, students should see some evidence of air pollution as air-borne particles stick to the tape around the jar. In some locations this pollution will come in part from natural sources. Since this activity detects only particulate pollution, students should be made aware that most air pollution is nonparticulate (SO_2, NO_3).

Measures that have been taken to reduce air pollution include lead-free gasoline and catalytic converters in automobiles, restriction of sulfur content in coal burned by industry, and use of scrubbers and electrostatic precipitators in smokestacks.

J-16. HOW HAS TECHNOLOGY INCREASED OUR ABILITIES?

(17)

PURPOSE:

To identify ways in which technology extends human ability.

PROCEDURE:

(1) Review with the class the technological examples from one or more of the following:

- the list developed in **Activity J-1**
- the list developed in **Activity J-11**
- examples listed in the "Concepts and Understandings"
- examples suggested by students.

(2) Ask students to identify which technological processes and devices have increased human ability and how they have done so.

RESULTS:

Advances in transportation modes allow humans to travel farther in a given time.

Movies allow repetitive showing of scenes not readily portrayed "live" in theatre.

Calculators/computers allow us to do complex calculations in shorter periods of time.

Microscopes allow us to see things too small to be seen with the naked eye.

Traffic lights, by supervising traffic flow 24 hours per day, allow us to travel more easily and safely.

Machines which dispense snacks allow us to buy food when there is no one to sell it.

Radio/TV and satellites allow us to see and hear events over longer distances.

Telescopes allow us to see things which are faint and far away.

J-17. WHAT IS THE BEST WAY TO LISTEN TO MY HEART?

(This activity is an extension of **Activity B-73** in **Block B, Living Systems: Human Systems**.)

(10, 11, 8)

PURPOSE:

To illustrate one area of technology that has progressively extended the abilities of humans.

MATERIALS:

a cardboard tube
a small funnel
rubber tubing
a stethoscope

Caution: Make sure stethoscopes are properly used.

PROCEDURE:

(1) Construct a simple stethoscope as described in **Activity B-73.**

(2) Which device, a cardboard tube, a simple stethoscope, or a commercial stethoscope, is best for listening to the heart? Devise a plan to answer this question, then carry it out.

(3) Which device was best? Why?

(4) How might people have first discovered that the heart makes sounds? How might they have used that discovery?

(5) The stethoscope extends our ability to hear sounds. What other technological devices extend our senses?

RESULTS:

Early physicians listened to heart sounds by placing their ears directly on their patients' bodies.

In 1816, Rene Laennec, a French doctor, discovered that a hollow wooden tube enabled him to hear heart sounds better because the tube excluded other sounds from his ear. Later, physicians discovered that a bell-shaped end to the tube worked even better. By stretching a thin diaphragm across the opening of the bell, physicians could hear higher-pitched sounds.

This activity allows students to determine for themselves which device best allows us to hear heart sounds, and to simulate the stages in the development of the stethoscope.

J-18. WHERE DOES NOISE COME FROM?

(This activity is an extension of **Activity G-31** in **Block G, Energy & Motion**.)

(8, 9, 10, 11, 12, 14, 17)

PURPOSE:

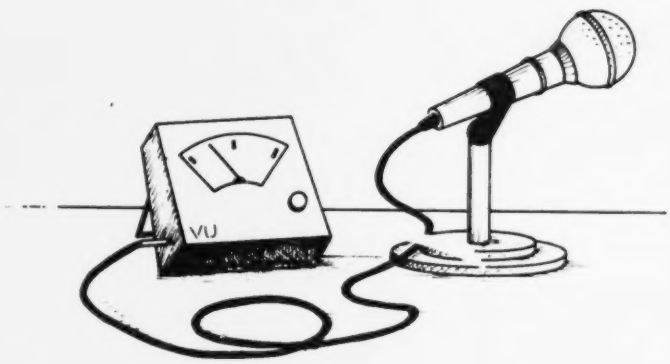
To illustrate how some technological processes and devices modify the environment.

MATERIALS:

microphone

sound (VU) meter (many tape recorders have a built-in sound meter and a microphone)

library reference materials



PROCEDURE:

(1) Do some technological devices and processes modify the environment by producing sound? Do some modify the environment in this way more than others? Plan how you could use the sound meter and microphone (as set up in the diagram) to answer these questions. Remember to include in your plan:

- a hypothesis (Which technologies do you think will modify the environment most or least?)
- an experimental design to test the hypothesis (What technologies will you test, and how will you test them?)
- a data table to record your results
- a method to evaluate your results

(2) Carry out your plan, and record and evaluate your results. Test as many technological processes and devices as you can, both indoors and outdoors.

(3) Which technological processes and devices modify the environment the most by producing sound? The least? Were there any which did not modify the environment in this way?

(4) Is sound modification of the environment a problem? Why or why not? What might happen to humans and other organisms in noisy environments? Use the library to research the effects of noise pollution.

(5) How could the sound produced by technological processes and devices be reduced? How can humans protect themselves from noisy technologies?

RESULTS:

Students should be able to design a procedure that will allow them to test many different technological processes and devices for sound level.

Sound levels will vary with the processes and devices tested. Some sample sound levels for different technological devices are given in the data table. Other sound levels can be found in **Appendix C-3** in **Block G, Energy & Motion**.

Sound Source	Decibels
weakest sound perceived	1
rustling leaves	20
refrigerator	35
washing machine	50
vacuum cleaner	5
hair dryer	70
power mower	90
city traffic (heavy truck)	90
automobile horn	105
jet takeoff	120
stereo (at high volume)	120

J-19. WHAT IS THE ORIGIN OF TODAY'S TECHNOLOGICAL PRODUCT OR DEVICE?

(13,17)

PURPOSE:

To illustrate how modern technological processes or devices build on past ones.

PROCEDURE:

(1) Construct at least five "technological chains." A technological chain shows how a technological process or device has changed over time. Some examples are given below to get you started. Start with a current technological process or device and, with the help of your teacher, your parents, and reference books, trace it back in time.

Examples:

- magnifying glass → eye glasses → hard contact lenses → soft contact lenses → astigmatic contact lenses → extended wear contact lenses
- Edison cylinder → 10" single disk (78 rpm) → 12" monaural disk LP (33 1/3 rpm) → stereo disk LP (33 1/3 rpm) → computerized digital compact disk
- handwriting → manual typewriter → electric typewriter → memory typewriter → dedicated word processor → computer word processing software
- electronic tube → transistor → electric chip (integrated circuit)
- direct communication → postal service → ground-level wire communication → ground-level radio communication → satellite communication
- rockets → unmanned satellites and space probes → manned spacecraft → Skylab → Space Shuttle → Spacelab → Space Telescope
- spring or brook → spring house → ice box → refrigerator → freezer
- abacus → adding machine or slide rule → calculator → computer
- drying → salting → sugar curing → pickling → canning → freezing → freeze drying

(2) For each technological chain that you've constructed, speculate on the next development in the chain. For example, the next step in printing words on a page may require merely speaking to a computer. The computer would transform your words into a printed page.

(3) Can you think of any "retronyms," which are words developed later to refer to earlier steps in the technological chain? Examples include the "analog" watch, which distinguishes a watch with hands from a digital watch; and the "manual" typewriter, which distinguishes a "non-electric" typewriter from the "electric" typewriter.

J-20. HOW HAS SHAVING TECHNOLOGY CHANGED?

(1, 2, 12, 4, 17)

PURPOSE:

To realize that an area of technology may change as a product is refined, or when a new technological breakthrough is applied to the basic problem.

PROCEDURE:

(1) Interview five men. Ask each one:

(a) what shaving device he began using,

(b) what shaving device he is presently using.

(2) During the interviews, complete the chart provided. Men representing each of the five age groupings shown should be sought for the interview. For each person interviewed, mark a "B" in the category for the razor first used and a "P" in the category for the razor presently used.

Data Table

Age of Men Interviewed

	18-24	25-35	36-50	51-65	66 +
straight razor					
single-blade safety razor					
electric razor					
double-track safety razor					

(3) In class, collate the results of students' interviews on a large version of the chart.

(4) Discuss the following questions.

(a) What are the advantages and disadvantages of each type of razor?

(b) Which razor is most popular today? Why might this be so?

(c) Have a number of men shifted from one type of razor to another type? Why or why not?

(d) Why might the double-track safety razors compete successfully with electric razors in the present day?

(e) What new technological breakthrough might occur in the future to further change the razor or even replace it?

RESULTS:

Students will likely find that the older men began shaving with the earlier razors and that some continue to use them. Young men probably began shaving with an electric or double-track safety razor.

Students may realize that the double-track safety razor represents a refinement of the single-blade safety razor in order to more effectively compete with electric razors.

J-21. WHY DO SOME TECHNOLOGICAL PROCESSES AND DEVICES DISAPPEAR?

(14, 17)

PURPOSE:

To identify why new technological processes and devices cause previous ones to become obsolete.

PROCEDURE:

(1) Show students a slide rule (or other obsolete device). Ask if anyone knows what it is or how to use it. Why is this tool no longer common? What device has replaced it? Why?

(2) Review your technological chains from **Activity J-19**. For each, what feature of the current technological process or device caused it to replace the process or device preceding it?

RESULTS:

There will be many specific reasons why a current technological process or device replaced one preceding it. In general, though, these reasons may be categorized into at least the following:

(1) necessity
(2) ease of use
(3) efficiency or profitability
(4) convenience
(5) marketability
(6) safety (to humans and the environment)

J-22. WHAT IS THE BEST WAY TO LAUNDER CLOTHES?

(8, 9, 10, 11, 12, 14)

PURPOSE:

To illustrate how current laundering products caused previous ones to become obsolete.

MATERIALS:

swatches of material
fruit juice
fat
caffeinated beverage
laundry soap
detergent
containers
water

PROCEDURE:

(1) How can you find out which laundering solution, plain water, laundry soap and water, or detergent and water, works best? Plan how you could answer this question. Remember to include the following in your plan:

- a hypothesis (Which method do you think will work best when compared to the others?)
- an experimental design to test the hypothesis (How will you stain the swatches? How will you prepare the test of the hypothesis?)
- a method to evaluate the results
- a data table to show the results

(2) Carry out the experiment, and record and evaluate your results. Which solution cleaned the stained swatches the best?

(3) Which solution is used to wash your clothes?

(4) Are your answers to the questions in (2) and (3) the same? If so, does this suggest why the other two methods are obsolete?

RESULTS:

A student plan may look like the following.
(1) Make three swatches of stained material by staining each swatch with fruit juice, fat or grease, and a beverage such as tea, coffee, or cola. Let the stain set for two or three weeks.
(2) Soak each of the swatches in one of these three solutions:
Solution #1: tap water
Solution #2: laundry soap and tap water
Solution #3: detergent and tap water
Make sure to use the same amount of detergent and soap in preparing the solutions. Soak for 24 hours.
(3) "Rate" how well the stained swatches were cleaned (0 = not effective, 1 = poor, 2 = fair, 3 = good, 4 = most effective).
(4) Prepare a data table of the results and keep the cleaned fabric as evidence.
Laundering with the detergent solution will generally be found most effective.

J-23. HAVE SOME TECHNOLOGICAL PRODUCTS BECOME CHEAPER?

(12, 14, 17)

PURPOSE:

To cite examples of products whose improvement has reduced their cost.

MATERIALS:

reference sources

PROCEDURE:

(1) Investigate the costs of the following items today and compare them with what your parents or grandparents paid for comparable items a number of years ago.

- radio
- calculator
- color television
- microcomputer

To compensate for inflation, divide the prices of these items by the cost of a standard item (a half-gallon of milk or a pound of bread) in the years compared.

(2) Which items have fallen in price over time? Use library reference books to find out why these items fell in price.

J-24. HOW DO SCIENCE, TECHNOLOGY, AND SOCIETY AFFECT EACH OTHER?

(17)

PURPOSE:

To show that changes in either science, technology, or society also affect the other two.

PROCEDURE:

Ask your students to suggest examples in which changes in science have affected technology and society and in which changes in society have affected science and technology. If they encounter difficulty, you might offer hints from the examples below.

RESULTS:

For changes induced by *science*, add to the science-technology relationships of **Activity J-10**.

laws of motion	space travel	new products, greater knowledge of universe
electricity	electrical appliances	more leisure time
electromagnetic waves	radio and TV	home entertainment
chemistry (chemical bonds)	synthetic materials	new products
radioactivity	nuclear medicine	better health
nuclear fission	nuclear reactors	reduced dependence on oil
structure of matter	microelectronics	increased calculative capability

Changes induced by *society* might include the following.

funding of medical research	medical research	new diagnostic techniques
prohibiting genetic engineering laboratories	restricted research	slow technological development

J-25. HOW LARGE CAN A FAMILY GET?

(12, 13, 14, 15, 17)

PURPOSE:

To illustrate that science and technology, through improved medical treatment and nutrition, can affect society.

MATERIALS:

the article, "One Man's Family," in **Appendix B-1**

PROCEDURE:

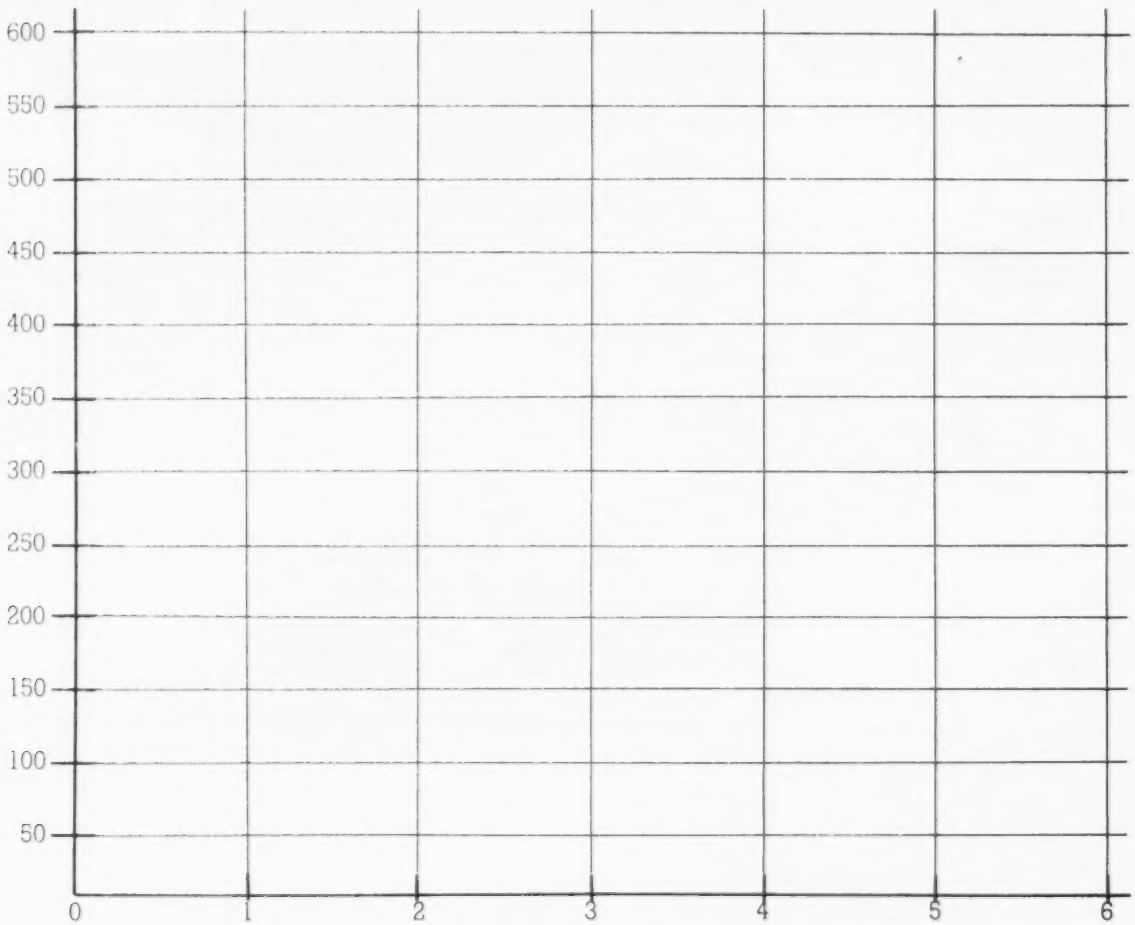
(1) Read the article, "One Man's Family."

(2) From the article, determine the number of surviving children, grandchildren, great-grandchildren, and great-great grandchildren John Miller had when he died. Record this information in a data table.

(3) Transfer the information from your data table to the graph provided. Consider Generation 1 to be John Miller and his wife (2 offspring), Generation 2 to be his children, Generation 3 his grandchildren, and Generation 4 his great-grandchildren. Do not graph Generation 5. Title your graph.

Graph

Title: _____



(4) Answer the following questions based on your graph and the reading.

(a) Why are there so few children currently in the 5th generation?

(b) What is the shape of the curve you got when you plotted the offspring in each generation?

(c) Estimate the number of offspring that there will eventually be in the 5th generation. If possible, make this estimate for the 6th generation. How accurate do you think you are?

(d) At the time of John Miller's death, what was the doubling time of his family?

(e) What was the factor largely responsible for the high survival rate in each generation?

(f) What was John Miller's major concern about the large size of his family?

(g) Do you agree with the conclusions in the last paragraph of the article? Why or why not?

(h) At the end of five generations, other families in the United States are not as large as John Miller's. Why?

(5) Trace your own family back as far as your oldest living grandparent, great-grandparent, or great-great grandparent. What is the number of currently surviving offspring from this one person? How does the number compare with the number of John Miller's offspring?

J-26. WHAT WERE THE "GOOD OLD DAYS" REALLY LIKE?

(7, 14, 17)

PURPOSE:

To illustrate that science and technology have changed society and our life-styles a great deal in the past century.

MATERIALS:

reference books

PROCEDURE:

(1) Work in groups of three. With the help of history of technology books and your teacher and other adults, answer the following questions.

(a) Using the fastest transportation available, how long would it have taken you to reach Los Angeles, California in 1885? How long would it take today?

(b) Using the fastest transportation available, how long would it have taken you to reach Tokyo, Japan in 1885? How long would it take today?

(c) How long would it have taken for a letter you wrote to reach Chicago in 1885? How long would it take today?

(d) How quickly would you have been able to contact a relative living in Dallas, Texas in 1885? How long would it take today?

(e) What would you have used to go shopping in a town 10 miles from your home in 1885? What would you use today? How long would a round trip have taken in 1885? How long would it take today?

(f) What might you have done to entertain yourself in 1885? For how many hours per week would you have been engaged in such leisure in 1885?

(g) What might you do to entertain yourself today? For how many hours per week would you engage in such leisure today?

(h) How many years would you have expected to live in 1885? How many do you expect to live today?

(i) What diseases that might have threatened you in 1885 have been virtually eliminated as threats today?

(j) What careers might you pursue today that were not available to you in 1885?

(k) How has improved technology caused the family to change from 1885 to today?

(2) Review and compare group responses to the above questions in class. Summarize your discussion with the following two questions.

(a) In what ways have our lives been made better by achievements in technology over the past century?

(b) What good things have been lost through the impact of technology over the past century?

RESULTS:

Students, in comparing the possibilities in 1885 and today, will realize that vast improvements have occurred in transportation, communication, health care, and personal opportunities. However, some may realize that such progress has come at the expense of the environment, national security, and the extended family. The key concept is that science and technology invariably change American and world society.

J-27. HOW HAVE CAUSES OF DEATH CHANGED SINCE 1900?

(14)

PURPOSE:

To illustrate that technological advances in medicine have reduced the rate of, or eliminated, some causes of death, while other causes of death have increased in rate, some because of technology.

MATERIALS:

graph paper
pencils
reference sources

PROCEDURE:

(1) Compare the two charts which list the leading causes of death in the United States. What diseases on the 1900 chart have disappeared from the 1980 chart? What diseases have been added to the 1980 chart?

(2) Make a bar graph of the five diseases that appear in both charts. Use different, but side-by-side bars for the 1900 data and the 1980 data.

(3) From the bar graph, answer the following questions.

(a) Which diseases increased in death rate over time? By how much did the number of deaths increase for each?

(b) Which diseases decreased in death rate over time? By how much did the number of deaths decrease for each?

(4) Use reference materials to answer the following questions.

(a) For each disease that increased in death rate, list three factors that may have influenced the increase.

(b) For each disease that decreased in death rate, list three factors that may have influenced the decrease.

(c) What disease not included in these charts has been eradicated in your lifetime?

Ten Leading Causes of Death in the United States in 1900

Cause	Deaths per 100,000 Population
cancer	65
kidney disease	85
stroke	110
diphtheria	40
senility	55
accidents	75
pneumonia and influenza	215
tuberculosis	185
diarrhea	140
heart disease	130

Ten Leading Causes of Death in the United States in 1980

Cause	Deaths per 100,000 Population
stroke	85
pneumonia and influenza	40
liver disease	30
homicide	15
diabetes	35
heart disease	340
accidents	95
cancer	185
suicide	20
artery disease	25

J-28. HOW HAVE JOBS AND CAREERS CHANGED IN THE LAST THIRTY YEARS?

(1, 2, 14, 17)

PURPOSE:

To investigate changes in business, industry, career choices, and employment brought about by science and technology.

PROCEDURE:

(1) Interview a retired person and ask the following questions. Record the answers.

(a) What was your first full-time job?

(b) How long did you continue to do that type of work?

(c) If you changed the type of work you did, what was the reason?

(d) How many different types of work did you do?

(e) Of all the types of work you did, how many of those jobs are still available today?

(f) What has replaced the jobs no longer available today?

(2) Interview someone who has worked in the same job at least 10 years and ask the following questions. Record the answers.

(a) What changes have you seen in your job in the past 10 years?

(b) Have computers affected your job?

(c) What changes do you expect to see in your job in the next 10 years?

(3) Interview a person who has been employed full time for less than 10 years and ask the following questions. Record the answers.

(a) Was your job newly created by some technological advance or was it performed by someone else before you?

(b) Do you use computers on your job?

(c) What change do you expect to see in your job in the next 10 years?

(4) Tabulate class results.

Retired persons:

- Number with same type of job entire life _____
- Number with two different types of job _____
- Number with more than two different types of job _____
- Total number of types of job _____
- Number still available today _____

Person working 10 years:

- Number with changes in jobs in the last 10 years _____
- Number affected by computers _____
- Number with changes in job expected in the next 10 years _____

Persons working less that 10 years:

- Number of jobs newly created by a technological advance _____
- Number of jobs previously performed by someone else _____
- Number of jobs using computers _____
- Number with changes in job expected in the next 10 years _____

(5) Plan a field trip to industries that are utilizing new technological devices or processes. If possible, select a company which has an employee "retraining" program. Observe the work people are doing.

(6) Write a brief paragraph describing your observations in (5).

(7) Look at the class data from (4) and your raw data from (1)-(3) and write two or three paragraphs that summarize how science and technology have affected business, industry, career choices, and employment in the last 30 years.

J-29. WHERE ARE THE JOBS AND CAREERS?

(1, 2, 14, 17)

PURPOSE:

To use newspaper classified sections to see what jobs and careers are available and what training is necessary for them.

MATERIALS:

classified sections from local and large-city newspapers

PROCEDURE:

(1) From the classified sections of the newspapers, cut out 10 "Help-Wanted" ads.

(2) List the training necessary to fill each of the jobs.

(3) As a class, discuss the following questions.

(a) How can an individual obtain the training necessary to change jobs?

(b) What can students do to prepare for a changing job market?

(c) Which of the jobs or careers interests you most? Why?

J-30. WHAT CAN WE DO ABOUT THE PROBLEM OF WORLD HUNGER?

(9)

PURPOSE:

To illustrate that science and technology alone cannot solve society's problems.

INTRODUCTION:

Most Americans get enough to eat, but more than one billion people who live in developing nations are classified by the United Nations as "seriously poor," and 500 million suffer from malnutrition. Many of their newborn children die and those who survive show the characteristics of old age as early as age 50. Many of these people would starve without the food exported by the United States. Others survive by exploiting their natural environment through overfishing, overgrazing, and deforestation.

MATERIALS:

magazine articles on world hunger

PROCEDURE:

(1) Locate and read at least two articles about a recent or ongoing famine somewhere in the world.

(2) In a group of three or four, discuss and answer the following questions.

(a) What is the problem to be solved?

(b) If you could get everybody to do what you wanted, what solution would you recommend?

(c) How successful do you feel your solution would be? Why?

(d) What problems do you foresee in feeding the world's population in the distant future?

(3) Have one member from each group report what the group concluded.

RESULTS:

The United States and other developed countries can teach underdeveloped countries farming techniques, resource management, and other techniques. However, in many places there is not enough rainfall for crops to grow, and overgrazing and overfarming are creating new deserts. To think that better crop management or better farming methods will solve the problem may be shortsighted. Other factors, some political, some social, also figure into the problem.

J-31. TO WHAT KIND OF NEED DOES TECHNOLOGY RESPOND?

(14, 17)

PURPOSE:

To identify the need for which a technological process or device was developed and to determine whether it was individual or societal.

PROCEDURE:

(1) Review with the class examples of technological processes or devices from the following:

- the list from **Activity J-1**

- the list from **Activity J-11**
- examples listed in the "Concepts and Understandings"
- examples suggested by students.

(2) Ask students to identify the need for each process or device and determine whether the need is individual or societal.

RESULTS:

While pencils were developed in response to the individual need to write, and public transportation in response to societal needs to move around, the reasons for the development of other technological processes or devices may not be as simple. Refrigeration, for example, meets both the individual need for food preservation and the societal need for better health so that the society can move on to address other problems.

J-32. WOULD YOU EAT IRRADIATED FOOD?

(This activity is an extension of **Activity G-94** in **Block G, Energy & Motion**.) **(8, 14, 17)**

PURPOSE:

To illustrate that acceptance of a technological process or device depends on the attitudes of individuals toward it.

MATERIALS:

Reader's Guide to Periodical Literature

INTRODUCTION:

Everywhere in the world, we throw away large amounts of food every day because the action of microorganisms has caused the food to become moldy or rotten. If we used ionizing radiation on these foods to kill the microorganisms, the loss of food would be significantly reduced. But the use of ionizing radiation in the United States is controversial, even though 24 other countries already irradiate food (1984 statistics).

PROCEDURE:

(1) Read the following passage.

There is a cooked ham on the table in the food-testing laboratory. It has been there for two months covered only by a piece of plastic wrap. It looks as if it had just come out of the oven, but it is not hot. There is a note next to it which says it was irradiated 52 days ago. The note also indicates that the ham was part of a test on preserving food by radiation and that the ham has been in the same spot ever since. The test has shown that the radiation has killed all the bacteria which could cause the ham to spoil but has not affected the taste of the ham or made it radioactive. You are invited to have some of the ham for lunch.

(2) In a group of three or four, discuss and answer the following questions.

(a) How do you feel about eating the ham?

(b) Why do you feel that way?

(c) What questions would you ask the scientists who tested the ham before making your decision?

(3) Have one member from each group report how the members of the group felt about eating the ham.

(4) Use the *Reader's Guide to Periodical Literature* to find several magazine articles on irradiated food. One heading to look under is "Food, Effect of Radiation On."

(5) Read at least two articles on irradiated food and take notes.

(6) Write a short report which summarizes the evidence for and against eating irradiated food. Include in your report a statement about whether or not you would eat irradiated food. Explain your decision.

RESULTS:

Student responses will vary. Some of the evidence for and against eating irradiated food is cited below.

Evidence for:

- The United States Food and Drug Administration says studies over 30 years find the process safe if irradiation does not exceed 100 kilorads.
- The United States Food and Drug Administration says no radioactive residue results.
- The United States Food and Drug Administration says no reduction in nutritional content occurs.
- Irradiation of food eliminates the need for chemical preservatives. (Some, like ethylene dibromide and nitrites, have been controversial themselves.)
- Improved technology uses electron beams instead of radioisotopes.

Evidence against:

- Some changes do occur in foods, producing new substances which may be harmful.
- Studies have not been conducted over a long enough time.
- Irradiation may increase aflatoxin, a suspected carcinogen.
- The United States Food and Drug Administration would not require labelling of irradiated food.

J-33. WOULD YOU DRINK WARM MILK?

(This activity is an extension of **Activity B-7** in **Block B, Living Systems: Human Systems**.)

(1, 2, 14, 17)

PURPOSE:

To show how attitudes can influence the acceptance of a product.

INTRODUCTION:

Milk can now be processed by using ultra high temperatures (UHT) and rapid cooling. It can then be stored on the shelf without refrigeration for six weeks. The packages it is stored in are lined with plastic which has been sterilized. This kind of packaging is called "aseptic packaging." Once the package has been opened, it must be refrigerated.

MATERIALS:

Reader's Guide to Periodical Literature

PROCEDURE:

(1) Use the *Reader's Guide* to locate magazine articles on aseptic packaging.

(2) Read at least two of the articles.

(3) In a group of three or four, discuss and answer the following questions.

(a) Where did this process originate?

(b) What conditions have made this process acceptable in Europe?

(c) What would the advantages/disadvantages of this process be to the store clerk? The dairy farmer? The customer?

(d) How do you think this process would help developing countries?

(4) A similar process is used to preserve fruit juices. Examine the grocery store shelves for products processed in this way. Answer the following questions.

(a) What products did you find?

(b) Are these products less or more expensive than those preserved by refrigeration, canning, and freezing?

(c) What are the advantages of these products?

(d) Have you tried any of these products? If so, did you like them?

(e) Are there other foods you would like to see packaged in this way? If so, what are they?

(5) Would you drink milk packaged in this way? Why or why not?

RESULTS:

Student responses will vary. Milk has been processed this way in Europe since 1961. Advantages of the process include the following.

- There is no need for refrigerated storage during transportation or at the point of sale.
- The product can be used when refrigeration is unavailable, as in developing countries or when a person is camping or backpacking.

J-34. WILL NO-TILL PLANTING BE ACCEPTED AS A FARMING PRACTICE?

(This activity is an extension of **Activities D-42** and **A-85**.) **(14, 17)**

PURPOSE:

To show that acceptance of a technological process depends on the attitudes of individuals or societies toward it.

INTRODUCTION:

Conventional plowing methods have contributed to the loss of half of the nation's topsoil during this past century, and the loss is growing. Conventional plowing produces "clean" fields and good weed control.

Recently, no-till planting, or planting without turning over the soil, has challenged old methods. The advantages of no-till planting include:

- Wind and water erosion are reduced when the previous season's crops remain in place.
- Less fuel is used in growing crops because both planting and herbicide application are done in just one trip over the field.
- Decreased evaporation increases the amount of water in the soil that can be used by the crop.
- Winter ground cover provides protection to wildlife.

PROCEDURE:

(1) Interview farmers, conservationists, and environmentalists in your area and report your findings on no-till planting.

Some sample questions which you might ask include:

(a) Is no-till planting better than conventional methods? Why?

(b) What are the disadvantages, if any, of no-till planting?

(c) Why do some farmers oppose no-till planting?

(d) Should we influence farmers to start no-till planting?

(e) How important is the conservation of topsoil?

(f) Do the benefits from no-till planting outweigh the burden of herbicide dangers?

(2) Discuss in class the views of farmers, conservationists, and environmentalists about no-till planting. What are your views? Why are these your views?

(3) Conduct a survey among farmers to determine how widely accepted no-till planting has become.

J-35. HAVE WE ACCEPTED UNIT PRICING AND GENERIC GOODS?

(1,12,14,17)

PURPOSE:

To show that acceptance of a technological process depends on the attitudes of individuals toward it.

(2) Survey at random 12 shoppers from each supermarket with the following questions.

(a) Do you use unit pricing in selecting what you buy?

(b) Do you buy generic goods? If so, do you feel that buying generic goods saves you money without sacrificing quality?

Data Table

		Name Brand		Generic Brand	
	Item	**Store #1**	**Store #2**	**Store #1**	**Store #2**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

PROCEDURE:

(1) Take a chart like the one provided to two different supermarkets. In each, examine the unit pricing on 10 name-brand items and 10 generic brands of the same item. Where possible, include at least two package sizes of the same item. Fill in the unit price on the chart as you examine each item.

(3) Tabulate the results for the entire class, then answer the following questions.

(a) Which of the above brands would you purchase in each supermarket? Why?

(b) Which supermarket appears to have better values?

(c) Does your tally of shoppers indicate that they use unit pricing while making their purchases?

(d) Do the shoppers at one supermarket seem more conscious of unit pricing than those at the other supermarket? If so, explain a possible reason.

(e) Does your tally of shoppers indicate that they buy generic goods?

(f) Do the shoppers at one supermarket seem more conscious of generic goods than those at the other supermarket? If so, explain a possible reason.

J-36. WHY ARE SOME INVENTIONS NOT ACCEPTED BY SOCIETY?

(8,14,17)

PURPOSE:

To consider why certain technological designs were never widely accepted.

PROCEDURE:

(1) Read the following list of patented inventions:

- a fake cigarette package that coughs loudly when picked up
- children's forks and spoons whose handles are made into musical whistles
- a beauty mask for women to wear at night while sleeping
- parakeet diapers
- a firecracker fire alarm
- a golf ball that sends out a smoke signal when it lands to help locate it
- a gun whose curved barrel extension allows it to shoot around corners
- a coffin with a tube for fresh air and an alarm
- an automatic baby-burper
- a gold trap which, when swallowed, is supposed to catch tapeworms

(2) In class, discuss why each of the above inventions has not become widely accepted.

(3) Suggest an invention that might be useful and describe it to the class.

(4) Poll the class to determine which student inventions are most popular. Which appear to be most useful?

RESULTS:

Each week, over 1000 inventions are registered at the United States Patent Office. Almost 4 million patents have been issued since 1790. Clearly, many of these innovations were thought to be more important by their inventors than by the society which neglected to use them.

(Patented inventions were selected from *Inventions Necessity is Not the Mother Of: Patents Ridiculous and Sublime* by Stacy V. Jones, Quadrangle/The New York Times Book, Co., 1973.)

J-37. HOW DOES TECHNOLOGY IMPACT GLOBALLY?

(5, 12, 14)

PURPOSE:

To show that technology may have widespread and even global impact.

MATERIALS:

reference books

PROCEDURE:

Part A

(1) Define the terms vaccine and immunization.

(2) Using a reference book, find out how the occurrence of disease is reduced and how diseases are eradicated.

(3) Discuss with your classmates what you have learned.

(4) How do vaccines affect world health?

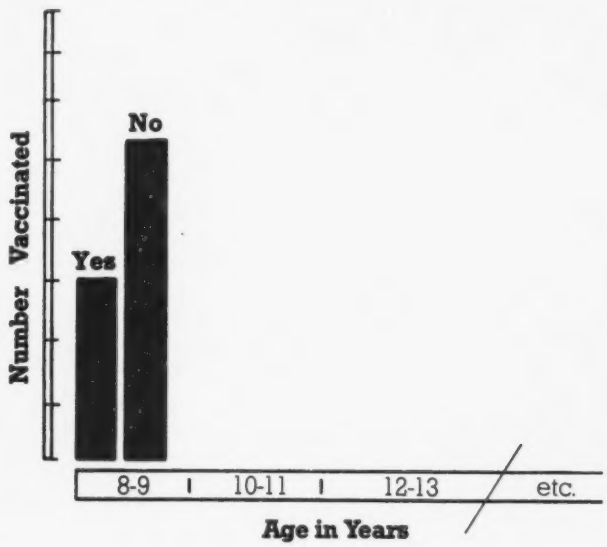
Part B

(1) Conduct a survey within your school building to find out how many people have and have not been vaccinated against smallpox. Ask their ages, and divide the people into the following age groups:

8-9 years	14-15 years
10-11 "	16-17 "
12-13 "	18-19 "
	20 + "

Make sure you have the same number of people in each age group.

(2) Graph your results on a bar graph like the following:



(3) What conclusions can you draw from your results? Are the numbers of smallpox vaccinations decreasing as the age groups become younger? If so, can you suggest a reason why?

RESULTS:

In May, 1980, following a lengthy eradication campaign, the World Health Organization declared the world free of smallpox. Smallpox was able to be eradicated only because it was transmitted by human-to-human contact. There were no intermediate hosts. Immediately following the WHO declaration, smallpox vaccination certificates as a condition for entry into another country were no longer required of international travelers. In May, 1983 distribution in the United States of smallpox vaccine for civilian use was discontinued. Student graphs should show a decrease in vaccinations at younger ages, with none occurring after 1983.

J-38. HOW DOES TECHNOLOGY AFFECT RELATIONSHIPS AMONG NATIONS?

(17)

PURPOSE:

To show that various technological processes and devices have an impact on relationships between the United States and other nations.

MATERIALS:

reference sources

PROCEDURE:

Have each student investigate and report on one of the topics below or on another effect of technology on international relations:

- the effect of electronics and automobile imports from Japan
- the effect of illegal farm workers from Mexico on American agriculture
- the effect of Mexican oil spills on the American Gulf coast
- the effect of acid rain on northeast Canada caused by midwestern American power plants
- the impact of American space technology on the communications facilities of other nations
- the effect of US-USSR cooperation in the exploration of space on other relationships between the two countries
- the effect of nuclear arms buildup by the United States and the USSR

J-39. HOW OFTEN DO I EAT AN "INTERNATIONAL MEAL?"

(12, 14, 17)

PURPOSE:

To show that the transport of food often results in individuals and nations interacting as a world community.

MATERIALS:

a world map or globe
reference books, including the *World Almanac*
cookbooks

PROCEDURE:

(1) Think about your favorite meal. In the chart provided, list the foods which comprise the meal. Be sure to break a combination food like pizza into its individual ingredients.

(2) Use the *World Almanac*, food packaging, cookbooks, and encyclopedias to learn where each of your food items was grown or produced.

(3) Locate on the map or globe the geographic origin of each of your listed foods. Then write the origin next to each food on your list in the column headed "Source." If more than one state or country is listed for a food item, look at the map and choose the closest state or country.

(4) Compile a list of international foods found in your local grocery store or speciality food shop.

(5) Answer the following questions.

(a) Roughly what percent of your favorite meal originated outside the United States?

(b) From how many different countries did the foods come? Which food came the longest distance?

(c) How many international foods are found in your local grocery store?

(d) What technological processes and products make it possible to have international products available in your local stores?

(e) What are some foods you eat that come only from other countries?

RESULTS:

Student results will vary depending on the meal chosen. Many foods are imported, particularly specialty foods and spices.

Adapted from "Mapping a Meal." Used with permission of the Solar Energy Education Project.

Data Table

Mapping Your Meal			
Menu	**Source**	**Menu**	**Source**

J-40. HOW FREQUENTLY DO I MAKE CHOICES ABOUT TECHNOLOGY?

(1,2,17)

PURPOSE:

To illustrate how many technological processes or products a person chooses among in a typical day.

PROCEDURE:

(1) On a chart like the one shown, make a list of the activities you engage in over the course of a day. Also, list the choices of technology available to you in doing each activity, and your actual choice.

Activity	Choices Available	Your Choice
brushing teeth	manual toothbrush/ electric toothbrush	
drying hair	hair dryer/towel and air	

(2) Answer the following questions.

(a) How many technological devices do you choose in a day?

(b) How many activities offer no choice of alternative technological devices? One choice? Two choices? Three or more choices? Make a bar graph of these data.

(c) Would you say that technology offers you increased choices in your life? Why or why not?

J-41. HOW HAVE THE CHOICES IN LEISURE TIME ACTIVITIES CHANGED OVER THE LAST FEW HUNDRED YEARS?

(17)

PURPOSE:

To show that technology has greatly increased the number of ways we can spend our leisure time.

MATERIALS:

reference books

PROCEDURE:

(1) Make a list of ways you can spend your leisure time (after school, evenings, weekends).

(2) Make a check next to the ways which were also available to your parents when they were your age.

(3) Make a second check next to the ways which were available to your grandparents.

(4) Make a third check next to the ways which were available to the Pilgrims who came over on the Mayflower.

(5) Place an asterisk in front of the ways which depend on technology. What relationship do you see between the asterisks and the check marks?

RESULTS:

Student lists may look like the following:

*√	Television
*√√	Movies
*	Video games
*√√√	Visit with friends
*	Watch movies at home on the VCR
*√√√	Eat
*√√√	Read
*√√√	Play games (non-video)

J-42. WHAT CHOICES DO WE HAVE IN EATING PROCESSED FOODS?

(1, 2, 14, 17)

PURPOSE:

To show that technology gives people increased choices.

MATERIALS:

fresh peas
dehydrated peas
canned peas
frozen peas
fresh refrigerated peas (a week)
cooking pans and hot plates
paper plates
fresh potatoes (optional)
a ricer (optional)
oven (optional)
commercially dehydrated potatoes (optional)

Part A

(1) Plan a blind taste test of fresh peas and peas preserved in different ways.

(2) Describe in a chart the taste and texture of each kind of peas.

(3) Which method of preserving peas do you prefer for taste and texture? How does this method compare with fresh peas?

(4) Is the method of preservation you chose the one you are used to eating? What factors influenced your choice of preservation method?

(5) Is this the method of preservation you prefer for all foods? Why or why not?

(6) Tabulate the class preference for preserved peas.

Part B (optional)

(1) How are foods dehydrated? Make your own dehydrated mashed potatoes by boiling potatoes until they are cooked, ricing them, and then placing them on a cookie sheet and drying them in a 220°F oven.

(2) Compare your homemade dehydrated mashed potatoes with a commercial brand in a blind taste test. Which did you prefer? Why?

J-43. WHICH WOULD YOU CHOOSE TO USE, A SLIDE RULE OR HAND CALCULATOR?

(1, 5, 14, 17)

PURPOSE:

To illustrate that people choose among technological devices based on their capabilities and limitations.

MATERIALS:

slide rule
hand calculators

PROCEDURE:

(1) Review your technological chains from **Activity J-19**. Select a technological device in the middle of each chain. Describe a capability the device you selected has, but that the one *before* it does not have. Describe one limitation this device has that the one *after* it does not have.

(2) Invite a person who can use a slide rule to demonstrate it to the class. Prepare a mathematics problem for the person to work out on the slide rule. Have classmates use hand calculators to do the same problem. Time how long it takes to solve the problem using each device. (You should average the times for the hand calculators.)

(3) What are the capabilities and limitations of the slide rule? The hand calculator?

(4) Which device would you choose to solve a long mathematics problem? Why?

RESULTS:

The slide rule is slower, limited to three significant digits, and requires a trained operator. The calculator may be faster, may require an external energy source, and requires some training of the operator.

J-44. IS TECHNOLOGY GOOD OR BAD?

(14, 17)

PURPOSE:

To show that whether a technological process or device is good or bad for society depends on how people decide to use it.

PROCEDURE:

Cite how each of the following technological processes or devices can be used to help or hurt society.

Data Table

Technological Process or Device	Good Use	Bad Use
drugs	(cure disease)	(dependence through abuse)
nuclear energy	(electricity)	(bombs)
rockets	(explore space)	(deliver bombs)
computers	(maintain information, increase calculative speed)	(computer crime)

RESULTS:

Indicated in parentheses.

J-45. DOES ACID RAIN AFFECT THE WATER ORGANISMS IN OUR ENVIRONMENT?

(This activity is an extension of **Activity A-78** in **Block A, Living Systems: Organisms**.)

(1, 2, 14, 17)

PURPOSE:

To illustrate that technological processes and devices have disadvantages to their use.

INTRODUCTION:

The oxides of carbon, sulfur, and nitrogen emitted by coal-burning power plants and industries and by our automobiles do more than pollute the air we breathe. When dissolved in rain, these oxides form an acid solution which affects our lakes and streams.

ADVANCE PREPARATION:

To prepare solutions, mix 10% H_2SO_4 and spring water as follows:

- pH 6 1000 ml spring water
- pH 5 1000 ml spring water + 10 drops 10% H_2SO_4
- pH 4 1000 ml spring water + 30 drops 10% H_2SO_4
- pH 3 1000 ml spring water + 50 drops 10% H_2SO_4

Allow solutions to stand overnight. Check pH and adjust as necessary.

MATERIALS: (per student team of 2-4)

about 15 *Gammarus* (can be found in ponds and streams on decaying vegetation or under rocks and debris and can also be ordered from biological supply houses)

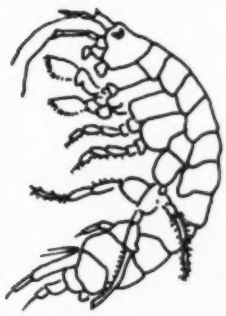
four 100 ml glass containers (baby food jars)

spring water

pH paper (range of 2-7)

masking tape

hand lenses (optional)



PROCEDURE:

(1) Half fill one of your glass containers with spring water at pH 6. Use masking tape to label the container. Place three or four *Gammarus* in this container. Observe their behavior.

(2) Answer the following questions about these *Gammarus*.

(a) Where do they spend most of their time in the container?

(b) What percent of their time is spent swimming?

(c) Do they use all of their legs in swimming?

(d) What do they do when they bump into one another?

(3) What do you think will happen to *Gammarus* in solutions of spring water that are more acid? (These solutions will simulate lakes and streams affected by acid rain.) State your hypothesis.

(4) Half fill one of your remaining containers with spring water at pH 5, another with spring water at pH 4, and the last with spring water at pH 3. Properly label each container.

(5) Check and record the pH in each container.

(6) Place 3 or 4 *Gammarus* in each container.

(7) Observe the behavior of the *Gammarus* in each container. Answer the questions in (2) for the *Gammarus* in each container. Since the observations will take more than a single class period to complete, students in other classes may continue your observations. If so, your teacher will share them with you and allow you to make final observations on the *Gammarus*.

(8) Compare your records of the behavior of the *Gammarus* in each container. Answer the following questions.

(a) What was the manipulated variable in this experiment?

(b) What was the responding variable?

(c) What was the control?

(d) What were the results of this experiment?

(e) What conclusion can you draw about the effects of acid solutions on living organisms such as *Gammarus*?

(f) What factors affect the pH of freshwater?

(9) Determine the pH of ponds, lakes, streams, and puddles in your area. Report the results in a data table. Based on your experiment with *Gammarus*, how do you think living organisms similar to *Gammarus* would do in the pHs you reported?

(10) (Optional) Study the effects of the pH solutions on the germination of pea or bean seeds.

RESULTS:

Over time, the *Gammarus* will show modified behavior in the acid solutions. The more acid the solution, the greater the effect.

Adapted with permission from Stubbs, Harriet S., *The American Biology Teacher*, April/May 1983, pp. 217-221.

J-46. HOW SHOULD WE ASSESS A TECHNOLOGICAL PROCESS OR DEVICE?

(14, 17)

PURPOSE:

To develop a process for assessing a technological process or device.

PROCEDURE:

(1) Using the chart provided, list the benefits and burdens placed upon people and the environment when each of the listed technological processes and devices are put into service in our society.

(2) Place an asterisk in front of each technological process or device for which you feel the benefits outweigh the burdens. Be prepared to discuss your reasons.

(3) How often did you and your classmates agree that a particular process or device should be (or should have been) adopted?

(4) How can people assess whether or not to adopt a technological process or device?

RESULTS:

Indicated in parentheses. Students should begin to realize that it is possible to assess technological processes and devices by the burdens and benefits they create. However, assessment depends on an ability to predict future consequences, which we may not always possess. When a decision is made to adopt or reject a particular process or device there may not be total agreement about that decision.

Data Table

Technological Process or Device	Benefit	Burden
nuclear energy	(additional electricity)	(risk of war, radioactive wastes)
mass transportation	(less pollution, less energy used)	(personal inconvenience, large cost)
robotics	(modernized, efficient industry)	(loss of jobs)
drugs	(treat diseases)	(dependence through abuse)
pesticide/insecticide	(increased agricultural yields)	(extinction of helpful species)
product packaging with synthetic materials	(fresher food)	(nonbiodegradable waste in landfills)
computers	(increased ability to process data)	(loss of jobs, health problems from video-display terminals)
space travel	(increased knowledge)	(high financial cost)
life-sustaining devices	(keep people alive)	(how to decide when to use or remove them)
organ transplants	(increased life span)	(cost, decision as to who receives them)
radioactive isotopes	(medical treatment and diagnosis)	(increased risk of cancer)
automobile	(increased mobility)	(increased pollution, deaths)
chemical fertilizers	(increased agricultural yields)	(eutrophication of lakes)
artificial sweeteners	(convenience for diabetics and dieters)	(increased risk of cancer)
nitrites	(prevent botulism)	(increased risk of cancer)

J-47. WILL WE BE SORRY TOMORROW FOR THE TECHNOLOGY WE HAVE USED TODAY?

(14, 17)

PURPOSE:

To show that some technological processes and devices have been used for their short-term benefits without attention to their long-term burdens.

PROCEDURE:

List the short-term benefits and long-term burdens of each of the following technological processes or devices.

RESULTS:

Indicated in parentheses. A valuable reference for information about the short-term benefits and long-term burdens of technological processes or devices is John W. Hill, *Chemistry for Changing Times* (Burgess Publishing Co., Minneapolis, MN, 1980).

Data Table

Technological Process or Device	Short-term Benefit	Long-term Burden
nuclear energy	(electricity)	(radioactive waste)
chemical fertilizers	(higher agricultural yields)	(eutrophication of lakes)
insecticides	(higher agricultural yields)	(extinction of helpful species while target pests acquire immunity, contamination of water supplies)
artificial sweeteners	(convenience for diabetics and dieters)	(possible increased risk of cancer)
strip mining	(increased fuel supply)	(unusable land, water pollution)
nitrites	(prevention of botulism)	(increased risk of cancer)
automobile	(increased mobility)	(increased air pollution)
modern-day packaging with synthetic materials	(fresher food)	(nonbiodegradable waste in landfills)
radioactive isotopes	(cancer treatment)	(increased risk of other cancer)
logging	(increased supply of wood products)	(deforestation of tropical jungles)

J-48. WHAT IS IN AN AEROSOL SPRAY?

(This activity is an extension of **Activity E-32** in **Block E, Weather and Climate**.) **(1, 14,17)**

PURPOSE:

To illustrate how a technological product can be modified to overcome its disadvantages.

INTRODUCTION:

The ozone of Earth's upper atmosphere shields life on Earth from the intense radiation of the Sun. This protective layer may, in fact, be one reason for Earth's ability to support life.

In the 1970's, there was a growing suspicion that pollution from high-flying aircraft, above-ground nuclear explosions, and aerosol spray cans was depleting our protective blanket of ozone.

What caused aerosol cans to threaten our ozone layer? Fluorocarbons -- the ingredient that makes those cans go "ffft"

PROCEDURE:

(1) Go to a local supermarket or drugstore and make a list of products sold in aerosol containers.

(2) Read several labels carefully and note the products that bear statements disclaiming fluorocarbons as propellents.

(3) What is the propellent in each product that disclaims fluorocarbons as the propellent?

(4) Look at each different kind of aerosol product. Is there alternative packaging for each type, such as a pump spray or squeeze bottle?

(5) Answer the following questions.

(a) What are the advantages of aerosol dispensers? Think of foaming shaving cream as an example.

(b) Fluorocarbons are still used in refrigeration units and heat pumps. Why is this use not a danger to the ozone layer?

(c) What other technological products can you think of that have been modified because of disadvantages in their use?

RESULTS:

Use of fluorocarbons as propellents in aerosol cans has been discontinued. Other propellents, such as hydrogen, are now used.

J-49. HOW DOES ONE DECISION LEAD TO ANOTHER?

(14, 17)

PURPOSE:

To show that sometimes one decision about a technological process or device can lead to other decisions about related processes or devices.

INTRODUCTION:

Technological advances in one area can cause great changes in other areas. Consider, for example, the development of wireless communication.

Radio → AM Broadcasting → FM Broadcasting → Television → Microwave Communications → Satellite Communication.

At each one of these steps, there are technological side branches, and at each one of these side branches, many decisions must be made. Radio, for example, has affected advertising, publicity, recording studios, copyright laws, the record industry, and many other endeavors.

PROCEDURE:

(1) Discuss the effect that each of the above developments in wireless communication has had on related industries.

(2) List 10 industries affected by any one of the above developments.

(3) For each of the 10 industries, show one or two decisions that would have to be made as a result of that development.

(4) Answer the following questions.

(a) What or who influences choices?

(b) Who makes decisions?

(c) How does the consumer influence decisions?

Note: *Connections* by James Burke (Little Brown, 1979) provides many examples of these kinds of branching decisions.

J-50. WHO RECEIVES AN ORGAN TRANSPLANT?

(14, 17)

PURPOSE:

To show the serious issues which may surround the use of a technological process.

MATERIALS:

recent newspaper and magazine articles about organ transplants

PROCEDURE:

(1) Read several articles about organ transplants, especially kidney transplants.

(2) As a class, discuss the following questions.

(a) There are more patients in need of kidney transplants than there are organs available. What is the fairest way of deciding who gets the organs available? Who should decide?

(b) Kidney dialysis machines and kidney transplants are very expensive and serve a relatively small number of people. What responsibility does government or society have for assuming the financial burden of these expensive procedures?

(c) If a person offered to sell a part of his or her body to someone in need of that part, should this be permitted?

(d) A person can survive if only one of the two kidneys in his or her body is functional. Should it be legally required that parents or children contribute one of their healthy kidneys to a child or parent if that is the only way to save the person's life?

(3) In your reading about organ transplants, what other issues did you find concerning transplants? Which of these are moral or ethical? Which are constitutional or legal? Why?

(4) Are the issues you have discussed and read about easy to resolve? Why or why not?

RESULTS:

Students should begin to understand that there are difficult issues surrounding the use of many technological processes and devices. These issues are controversial, and there are generally no easy solutions.

J-51. WHAT ISSUES SURROUND THE USE OF LIFE-SUPPORT SYSTEMS?

(14)

PURPOSE:

To show that the use of a technological process or device may lead to serious moral, ethical, constitutional, or legal questions and issues.

INTRODUCTION:

Medical advances in recent years have raised questions about death which did not exist in earlier times. In the past, death occurred clinically when heartbeat and breathing stopped. Now, with artificial life-support systems, these functions can often be maintained for long periods of time, even years. As a result, a new definition of death, brain death, is becoming accepted. Brain death occurs when spontaneous brain function ceases. Because transplant organs are best taken as soon as possible from a dying person, defining the point of death is particularly important when the person is donating organs. The legal definition of death is no longer as simple as it used to be.

At the same time, prolonging life artificially can cause pain for the patient, expense for the family and society, and suffering for relatives. Some people object to the enforced use of life-support systems. They argue that these systems are violating a basic human right, the "right-to-die" and to do so with dignity. The right-to-die conflicts with other social values: the sanctity of life, the "sin" of suicide, or even what constitutes murder.

In response to the technology of life support, some people have drawn up "living wills." A living will instructs doctors to cease artificial life support when there is no chance for the person to recover, and when there is great pain and suffering.

A living will is an attempt to create a legal document that allows a person to decide about death while the person is still capable of rational decisions. Living wills and the right-to-die concept are still very controversial.

MATERIALS:

recent newspaper and magazine articles about issues surrounding life-support systems

PROCEDURE:

(1) Read several articles about the issues surrounding the use of life-support systems.

(2) As a class, discuss the following questions.

(a) Should people be allowed to decide for themselves the conditions under which they should be allowed to die? Why or why not?

(b) Should life be sustained as long as possible?

(c) Are doctors, nurses, or relatives ever justified in "pulling the plug?"

(d) How could society resolve the conflict between an individual's "right-to-die" and society's duty to protect human life?

(e) Should living wills be legally binding?

(f) Could living wills and the right-to-die be abused? How?

RESULTS:

Students should begin to understand that many issues can arise when a new technological process or device is adopted. These issues have no easy resolution, especially when individuals' attitudes on the issues depend on the particular values they hold.

J-52. WHO OWNS THE SUN?

(This activity is an extension of **Activity I-60** in **Block I, Energy: Sources and Issues**.)
(14, 17)

PURPOSE:

To explore the issues surrounding the use of the Sun's energy.

MATERIALS:

reference books and magazines

the article, "A Sun Rights Dilemma," in **Appendix B-2**

overhead projector and transparencies

PROCEDURE:

(1) Working in groups of four or five, read the dilemma provided.

(2) Discuss the pros and cons of introducing solar energy into the town. Add to the list of pros and cons already given you in the dilemma.

(3) Discuss the possibility of introducing laws that might protect citizens wishing to use solar energy.

(4) Come up with five possible solutions to the dilemma.

(5) Appoint a recorder and have that person write your five solutions on an overhead transparency and report them to the class.

(6) In your group, or individually, research whether or not an individual has legal access to the Sun, either statewide or locally.

(7) Where do you think the responsibility for deciding access to the Sun should lie, with the local, state, or Federal government? Why?

(8) Is it possible to provide access to the Sun in cities? Why is this a difficult problem?

RESULTS:

In the past in the United States, a person's legal access to the Sun has not been clear. However, many states and municipalities are now writing statutes and zoning ordinances that protect an individual's right to the Sun.

Adapted from "A Sun Rights Dilemma," *Renewable Energy Activities*, © 1984 by the Research Foundation of SUNY on behalf of the New York Energy Education Project. Used with permission.

J-53. HOW DO WE MAKE DECISIONS ABOUT TECHNOLOGICAL PROCESSES OR DEVICES?

(14, 17)

PURPOSE:

To show that a complex technological issue often has several possible solutions and that trade-offs are often made among these solutions

MATERIALS:

reference books and magazines

recent newspaper articles about technological issues

PROCEDURE:

(1) Read several magazine and newspaper articles about one of the following technological issues:

- the need for additional amounts of energy
- disposal of toxic wastes
- disposal of radioactive wastes
- contamination of ground water supplies
- genetic engineering

- artificial organs
- between-species organ transplants

(2) As a class, discuss and list all the possible alternative courses of action to solve the technological issue.

(3) As a class, decide which alternative course of action should be followed. You may have to come up with a compromise course of action.

(4) Answer the following questions.

(a) How difficult was it to make a group decision about the proper course of action?

(b) To what degree did individuals have to make compromises?

(c) If experts were to become involved in the decision-making about the issue you chose, from what disciplines might they come? To what extent do you think these experts would agree on the solution?

(5) Invite a person who is involved with policymaking to speak to the class about how individuals and government make decisions and set policy.

J-54. SHOULD THERE BE A SEAT BELT LAW?

(This activity is an extension of **Activity G-8** in **Block G, Energy & Motion**.) **(14,17)**

PURPOSE:

To show that society, through government, passes laws to regulate a technological process or device.

PROCEDURE:

(1) Do **Activity G-8** and the activities in the National Science Teachers Association's "Seat Belt Science: Activities for General Science."

(2) Interview 12 people about New York's seat belt law by asking the following questions.

(a) Do you feel that the law takes away your freedom to decide to use a seat belt or to take the risk or not using it?

(b) Do you feel that the seat belt law is justified?

(3) Tabulate class results.

(a) How do most people feel about the seat belt law?

(b) Why do you think the Legislature passed this law? Do you agree or disagree with the Legislature? Why?

J-55. WHY DOES GOVERNMENT CONTROL CERTAIN TECHNOLOGICAL PROCESSES AND DEVICES?

(14,17)

PURPOSE:

To show that government regulates technological processes and devices for the welfare of people.

PROCEDURE:

(1) For what reasons was each law listed below enacted?

- seat belt law
- minimum drinking age
- minimum tobacco purchase age
- establishment of illegal drugs, such as marijuana or heroin
- ban on smoking in some public places
- smokestack emission control laws

- reclamation laws for strip-mined land
- ban on littering
- automobile emission control laws
- noise control laws
- bottle bill
- drunk driving laws
- hunting and fishing regulations
- mandatory smoke detectors in new residences

(2) How many of the laws above are related to a principle of science? What are some of these principles?

(3) Conduct a survey of your class, school, or neighborhood on one or more of these laws. How many people agree with each law you chose? Disagree? Does everyone have to agree for a law to be enacted?

RESULTS:

Students should begin to realize that some technological processes and devices are regulated for the public good. While not all will agree with the laws regulating these processes and devices, people give up their individual rights to obey them.

J-56. HOW SHOULD WE SPEND OUR MONEY FOR SCIENCE AND TECHNOLOGY RESEARCH?

(17)

PURPOSE:

To distinguish science from technology and engineering, and to illustrate the trade-offs that are made in funding research and development.

INTRODUCTION:

Science is the discovery of concepts and principles about the natural world for the purpose of extending knowledge. Technology and engineering are the application of those concepts and principles to solve problems. *Technology* uses scientific knowledge and other resources to develop products and processes for the benefit of people. Science often has practical technological applications, although they are not usually immediately obvious.

Limited public funds for scientific research and technological development require us to set priorities and make trade-offs among projects. How is this decisionmaking done?

PROCEDURE:

(1) Divide the class into groups of 4-6 students. Each group is to act as a senate committee for appropriation of funds for science and technology research.

(2) In your group, work through the exercise provided, and then report your decision to the class, which will act as a full senate.

(3) With the class, discuss the group reports. Then, make a final decision on the projects to be funded. State the senate's reasons for funding each project.

(4) Answer the following questions.

(a) How difficult was it for your group to arrive at its decision? What were the problems encountered in reaching the decision?

(b) In each area of research, what kind of project was funded? Of the four projects funded, how many were science? Technology? If there is any consistency to the kind of projects funded, suggest a reason for it.

(c) What processes did your group and the class go through in reaching their decisions?

(d) Many organizations conduct telethons to raise money for medical research. Could this be a way to raise money for other kinds of science and technology research? Why or why not?

EXERCISE:

Listed below are four areas of research, with proposed research projects in each area. In your group:

- identify which project in each area is science, and which is technology
- select one project from each group for funding. State your reasons for funding that project.

Research Area	Research Projects
A. Cancer	1. Studying the cycle of growth and division in normal and cancer cells.
	2. Developing a better version of a machine which has already proved successful in detecting cancer.
B. Pollution	1. Developing improved methods of removing pollutants from factory smoke stacks.
	2. Studying the effects of acid rain in freshwater lakes.
C. Education	1. Developing educational software for computers.
	2. Studying the effect of diet on learning in monkeys.
D. Energy	1. Studying the Sun's production of energy by nuclear fusion.
	2. Developing a method of using fusion to generate electricity.

RESULTS:

The projects in each area of research should be identified as follows:

Area A	1. Science 2. Technology	Area C	1. Technology 2. Science
Area B	1. Technology 2. Science	Area D	1. Science 2. Technology

The projects funded will vary from group to group.

APPENDIX B —RESOURCES

B-1. ONE MAN'S FAMILY

by Glenn D. Everett

Recently, on the eve of his 95th birthday, John Eli Miller died in a rambling farmhouse near Middlefield, Ohio, 40 miles southeast of Cleveland, leaving to mourn his passing perhaps the largest number of living descendants any American has ever had.

He was survived by five of his seven children, 61 grandchildren, 338 great-grandchildren, and six great-great-grandchildren, a grand total of 410 descendants.

Shortly before his death, which came unexpectedly from a stroke, I had the privilege of two long visits with John E. Miller, during which I learned the feeling of one man who had personally watched the population explosion of the 20th century. A national magazine had determined that the venerable Ohio farmer was head of what almost certainly was the largest family in the United States.

A Swedish newspaper in 1958 ran a competition for the largest family in that country and when a family named Hellander turned up with 265 members, headed by a 92-year old great-grandmother, it asserted a claim to the Swedish and to the world championship.

Soon the reports of even larger families were streaming into editors, with an elderly Mormon couple in Utah claiming 334 living descendants taking the lead. However, I was certain that among the Old Order Amish Mennonites, a sect in which families of more than 100 are commonplace, a family larger than this could be found. Through the medium of the Sugarcreek, Ohio, *Budget*, a unique weekly newspaper that is read by the Old Order Amish in all their communities throughout the Nation, it was soon ascertained that John Eli Miller, with his clan of more than 400, had the largest family among them. So far as could be learned, this family was the largest in America and probably the world's largest among monogamous peoples.

When John Miller and his family refused to pose for photographs because of their religious opposition to "graven images," the magazine gave up the idea of a story about this "largest family" but the interviews disclosed a number of facts about the impact of extremely rapid population growth on this family and the cultural group of which it is a part. These facts merit the serious attention of all students of population problems.

John Miller actually had seen with his own eyes a population explosion in his own lifetime. His data were not statistics on a graph or chart, but the scores of children at every family gathering who ran up to kiss Grandpa, so many that it confused a poor old man. His confusion can be forgiven for there were among them no less than 15 John Millers, all named in his honor. And what young man, much less an old one, could remember the names of 61 grandchildren and 338 great-grandchildren and keep straight just who their parents were?

The remarkable thing about this great clan of his was that it started with a family of just seven children. This was actually a little smaller than the typical family among the Amish, who have been found by one researcher to average 8.4 children per completed family. Two of his children died in early life: Samuel Miller, who left six children when he died at 40, and Lizzie (Mrs. Jacob Farnwald), who left four when she died at 28.

During most of his long life, therefore, John Miller's family was not unusually large. It is just that he lived long enough to find out what simple multiplication can do.

One of his daughters, Mary (Mrs. Jacob Mast) had only five children. But all four of his sons had quite large families. His son, John, Jr., with whom he lived in the

family homestead, had six children by his first wife, who died in an accident, and nine more by his present wife, a total of 15. Andrew Miller had 12, Eli Miller, 11, of whom ten are living, and Joseph Miller, 10, of whom nine are living.

Of the 63 grandchildren born to John Miller's family, 61 lived to survive him, all but six now grown and married. And of 341 great-grandchildren born to the families of his 55 married grandchildren, only three had died, two in infancy and one in an accident. All six of his great-great-grandchildren were born during the last year of his life and were healthy infants.

Thus, a major factor in the worldwide population crisis was vividly evident in John Miller's family: the fact that nearly all children born in the 20th century, who enjoy the benefits of modern medicine, are growing up to become adults and to have families of their own. A century ago, the ravages of smallpox, typhoid fever, tuberculosis, diphtheria and the many fatalities that occurred at childbirth would have left a far different picture in a large rural family. Even though the Amish live in rural areas, they avail themselves of the benefits of medical care. Now most Amish children are born in hospital delivery rooms.

While the sharp reduction in infant mortality and childhood disease is a happy development of science, it inevitably means that population grows with extraordinary rapidity. The Miller family offers a cogent example. John Miller had seven children; his children averaged nine offspring; and his married grandchildren had averaged six each when he passed away. Six married great-grandchildren had one apiece. These were not unusually large families among the Amish nor among the rural families of other Americans in the past century. Yet this clan numbered 410 when John Miller died.

Moreover, at the end of his life, the postman was bringing John Miller word of the birth of a new descendant on the average of once every ten days. This rate, we calculated, would have accelerated to one every other day as his more than 300 great-grandchildren reached marriageable age. Only eight were married when he died and six had had children by their first wedding anniversaries.

So great is the rate of progression of population growth that had John Miller lived one more decade he would have seen more descendants born to him than in all his 95 years of life and would in ten more years have counted at least 1000 living descendants!

The rate at which population increases is almost unbelievable, even when a man is watching it happen within his own family. John Miller found it difficult to comprehend what was happening. When I told him that all available evidence indicated that he had the largest family in the United States, the kindly old man passed a gnarled hand before his failing eyes and shook his head in amazement.

What did John Miller think about his family? Did it worry him to see it growing so large? Indeed it did. Significantly, his concerns were the very ones that the demographers, the economists, the sociologists, and other serious students of world population problems have been voicing. He was not an educated man, for the Amish still believe eight grades of education in a one-room country school is sufficient, but John Miller summarized it in one simple question he constantly repeated, "Where will they all find good farms?"

Some day, at some point, John Miller's plaintive question, "Where will they all find farms?" will have to be answered in the bleak negative. They can continue now only by buying farms others will sell them. Some day no more farms anywhere will be for sale. A finite world is of limited size. So, ultimately, at some point, is the population it can hold.

Reprinted with permission, *Population Bulletin*, 17(8):41-44, 1961.

B-2. A SUN RIGHTS DILEMMA

The year is 1990; the United States' energy crisis has deepened. Gasoline now costs $3.29 per gallon and prospects are that it will hit $4.00 by 1991. The prices of home heating oil and natural gas continue to rise. The energy picture is not bright. Although a number of nuclear plants are still in operation, people have not yet forgotten the incident at Three Mile Island, and few new plants have gone into operation since 1980.

In a small town in the U.S., Anytown, the people are very much aware of the energy crisis that has reached into every home and business across the country. Anytown is a familiar spot to many people. Its history goes back to the 17th century when America was first being settled. The citizens of the town are proud of their heritage and have promoted the town as a historic site. They have preserved the historic character of all the buildings of the town. The town is a tourist attraction, and during the summer many families come to enjoy the rich past that is preserved here.

The people of Anytown are conscious that something needs to be done about the energy crisis. Some strongly believe that the way to end United States energy dependence on oil (a problem the United States has been trying to deal with since 1973) is to enforce stricter conservation methods. Others feel there is a need to develop and emphasize more use of coal and nuclear power. However, another group of citizens in the town has been doing some investigating regarding alternative energy sources — particularly the use of solar and wind energy. One industrious individual, Ms. Swift, has even gone so far as to construct a small bank of *active solar collectors* in her yard to show her friends and neighbors how the whole town could benefit from the use of solar energy. At the present time, Ms. Swift uses her active solar collectors to heat the hot water in her home; but she has told her friends that it is also possible to construct a *passive solar home* which could save thousands of dollars in heating bills.

At the same time, Mr. Johnson is having problems with energy costs at his farm on the edge of town. In order to make himself more energy independent, Johnson intends to install a *wind-powered generator* on a 30-meter tower to meet most of his energy needs. He plans to contribute any excess to the town electric service. He has applied for a building permit.

Unfortunately, the desire on the part of some of the people to use solar energy has brought about a legal battle within the town. There are a few problems that have to be dealt with and the town council is about to hear the arguments of the people involved. First of all, there exist some strict zoning ordinances in the town regarding what can be built. Since this town is a preserved historic site, laws have been passed that prevent additions to already existing houses or the building of new houses that appear to be out of keeping with the history of the town. The Anytown Historical Society strongly opposes building passive solar houses or putting solar collectors on the roofs of people's houses, as well as the installing of windmills. They maintain that the law forbids such things and plan to see that the law is enforced.

In addition to this, a second set of problems has arisen. After Ms. Swift built her solar collector on her property, Mr. Jones, vice-president of the historical society, who lives next to Ms. Swift, promptly planted five poplar trees, even though the collectors are screened from the street by a hedge. Poplar trees take only a couple of years to grow and provide a great deal of shade. The result is that Ms. Swift's solar collector will soon be useless because of the poplar trees which will shade the collector from the Sun. This might force Ms. Swift to abandon her project altogether.

Meanwhile, Ms. Fagel, Johnson's neighbor, says that a windmill can make enough noise to bother her on her peaceful farm, as well as interfere with reception on her television. Ms. Fagel is in favor of *energy conservation*. She says that Johnson could save just as much energy by adding more insulation to his house, and that he should forget about the wind generator. The town is considering denying Johnson's building permit because of her complaints.

The next town meeting will be the arena for discussing the following issues:

1. The historical committee wants stricter enforcement of the zoning laws in the town to prevent the introduction of solar collectors and other innovations to the town. They want present collectors dismantled.
2. Ms. Swift has decided to confront the town with her belief that she has a constitutional right to the Sun,

and if someone prevents her access to the Sun, it is wrong. She wants Mr. Jones to take out the poplar trees which will shade her collector.

3. Mr. Johnson wants to establish just what his rights are as a property holder in his town. Does some group sitting in town office, elected by him, have the right to tell him what he can and cannot build on his property?

Now the people in the town are divided into two camps — those wishing to preserve historic tradition and the financial gain that comes from tourism, and those who wish to introduce solar and wind energy into their homes and change existing laws so that they will be protected. In addition, a third group feels that all the town's energy problems could be solved by more conservation, without needing solar collectors or wind generators.

Now add more pros and cons to this list.

Pro-Solar	**Anti-Solar**
1. will cut down on dependence on oil and electricity	1. disturbs the historic beauty of the town
2. will ultimately be less costly	2. people will stop coming to the town — will mean a loss of revenue
3.	3.
4.	4.
5.	5.
6.	6.
7.	7.

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APPENDIX C —EXCERPTS FROM A NATIONAL SCIENCE TEACHERS ASSOCIATION POSITION STATEMENT

SCIENCE-TECHNOLOGY-SOCIETY: SCIENCE EDUCATION FOR THE 1980'S

Preamble

Science and technology influence every aspect of our lives. They are central to our welfare as individuals and to the welfare of our society. All around us are examples of the importance of science and technology for production of food, shelter, clothing, medicines, transportation, and various sources of energy. There is an increasing number of science- and technology-related societal problems as well as increasing societal benefits. Science and technology are central to our personal and cultural welfare *and* to many societal problems. We must insure appropriate science education for all citizens.

However, the quantity and quality of science education for all people are not commensurate with the status of science and technology in society. When one would expect budgets, time spent on science-related subjects, and support for science education to be increasing, they are decreasing. At the same time these factors are declining, societal problems continue to require an understanding of science and technology. The burden of response rests heavily upon the shoulders of *all* persons associated with science endeavors — scientists, engineers, classroom teachers, other educators, and school administrators. Many of the problems we face today can be solved only by persons educated in the ideas and processes of science and technology. A scientific literacy is *basic* for living, working, and decisionmaking in the 1980's and beyond.

There is a crisis in science education. The following science-technology-society problems demand immediate attention:

- understanding of science and technology are central to our personal and national welfare, yet public appreciation of science education has declined;
- increasing numbers of individual and societal problems which have an impact on the quality of life are related to science-generated technology;
- as the impact of science and technology on society has increased, the support for science education has decreased;
- compared to its recent past the United States has fallen behind in the production of scientific and technological goods and services; and
- women, minorities, and handicapped persons are underrepresented in nearly all professional and technical rolls in science and technology.

Declaration

The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decisionmaking. The scientifically literate person has a substantial knowledge base of facts, concepts, conceptual networks, and process skills which enable the individual to continue to learn and think logically. This individual both appreciates the value of science and technology in society and understands their limitations.

The attributes listed below help to describe a scientifically literate person. Each attribute should be thought of as describing a continuum along which the individual may progress. The progress of the individual's science education should be equated with progress along this continuum.

The scientifically and technologically literate person:

- uses science concepts, process skills, and values in making responsible everyday decisions;
- understands how society influences science and technology as well as how science and technology influence society;
- understands that society controls science and technology through the allocation of resources;
- recognizes the limitations as well as the usefulness of science and technology in advancing human welfare;
- knows the major concepts, hypotheses, and theories of science and is able to use them;
- appreciates science and technology for the intellectual stimulus they provide;
- understands that the generation of scientific knowledge depends upon the inquiry process and upon conceptual theories;
- distinguishes between scientific evidence and personal opinion;
- recognizes the origin of science and understands that scientific knowledge is tentative, and subject to change as evidence accumulates;
- understands the applications of technology and the decisions entailed in the use of technology;
- has sufficient knowledge and experience to appreciate the worthiness of research and technological development;
- has a richer and more exciting view of the world as the result of science education; and
- knows reliable sources of scientific and technological information and uses these sources in the process of decisionmaking.

Recommendations for Middle/Junior High School Science

The middle/junior high school science curriculum should be designed to accommodate the needs and learning styles of the early adolescent. Students should be provided with daily opportunities to explore science through reading, discussion, and direct learning experiences in the classroom, laboratory, and field.

Middle/junior high school science should contribute to the development of scientifically literate persons and not simply prepare them for the next science course. National studies have shown that often middle/junior high school science is designed to prepare students for high school biology with no emphasis on physical science. In addition, studies show that fewer than one-half of the junior high students going on to high school take chemistry and physics. Therefore, it is imperative that an important thrust of middle/junior high school science be toward the physical and earth sciences.

Middle/junior high school students should continue to develop science process skills and content. Middle/junior high school science should emphasize the *application* of both skills and content to the students' personal life situations and enable students to begin examining societal issues that have a scientific and technological basis. Middle/junior high school students need to *apply* what they have learned soon after their instruction to insure the lasting value of the experience.

Time on science learning

Middle/junior high school level (grades 7-9): a minimum of 1 hour/day for at least 2 full years of science should be required for all students.

Emphasis on programs for all students

In elementary, middle, junior high, and senior high school grades, science education programs should provide basic concepts for all students. Opportunities should be available for students with diverse interests and commitments, including students with exceptional interests and talents in science.

Emphasis on laboratory and field activities

Middle/junior high school level laboratory and field activities should stress the application and extension of inquiry skills as a means of obtaining knowledge and resolving problems.

Science instruction matches students' cognitive, physical, social, and emotional development

Schools should provide objectives, content, and instructional strategies that are appropriate to the student's stage of mental, moral, and physical development.

Varying strategies and materials should be provided at all grades to accommodate students with various levels of learning skills and mental development.

Emphasis on science-related societal issues

Middle/junior high school level: a minimum of 15 percent of science instruction should be directed toward science-related societal issues.

The entire NSTA Position Statement was adopted unanimously by the Board of Directors in 1982. Additional copies of the position statement are available. Write to the National Science Teachers Association, 1742 Connecticut Ave., N.W., Washington, DC 20009.

APPENDIX D — PROBLEM-SOLVING

1. Definition of the Problem

Before a student can solve a problem, the student must recognize that there is a problem to be solved. To help your students recognize a problem, use their **EXPERIENCES** to make them aware of **DISCREPANCIES**. The discrepancies should lead them to raise **QUESTIONS**, and the questions will help them to define the problem.

EXPERIENCES can be both spontaneous events and teacher-planned activities. The experiences you choose for instruction should be ones that make a student aware of discrepancies.

DISCREPANCIES are differences, inconsistencies, disagreements, or disharmonies that we encounter. A discrepancy becomes evident only when we have some prior experience or basis for comparison.

Discrepancies may be grouped into six general categories. An example for each is included.

A goal to achieve without a means to achieve it.

- A person needs to fix a pair of eyeglasses, but has no replacement screw.

A difference between what the student expects to observe and what the student actually does observe.

- Ice sinks in a liquid.

A lack of knowledge — others may know the information, but the student does not.

- Acid rain results in the deterioration of some buildings and statues.

A difference between what the student has been told is true and what the student has already verified personally.

- A student is told that light-colored objects become hotter in sunlight than dark-colored objects, but knows that the reverse is true.

A conflict (internal or external) between interpretations, opinions, attitudes, or values.

- A person wants to experience wilderness, but takes a battery-powered radio on a camping trip.

A difference between an existing set of conditions (what is) and a desired set of conditions (what should be).

- People are starving in some areas of the world.

QUESTIONS play a vital role in problem-solving because they help to identify and define the problem and to guide the systematic search for a solution. Once a student recognizes a discrepancy, he/she should be encouraged to construct many questions about it. It is important that students be taught to construct precise questions. When a student has constructed a precise question, the student has more clearly identified the problem.

Questions can be used to focus inquiry. The categories of questions and the focus of each include:

Category	Focus
who?	a person or group
what?	an object or event
when?	time
where?	a location
which?	a choice (alternative)
why?	a reason or explanation
how?	a procedure or process
what if?	speculation

2. Model for Problem-Solving

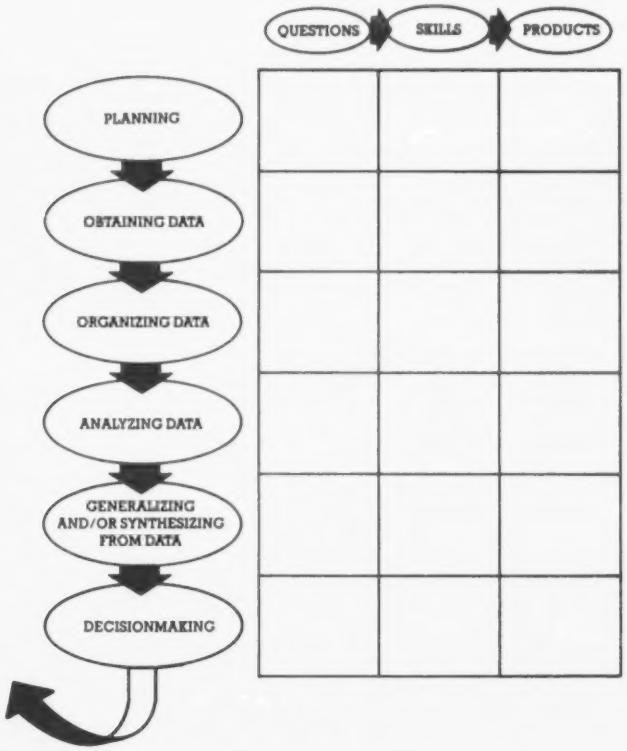
Once a student has identified a problem by constructing a precise question, the student can proceed with problem-solving.

The model for problem-solving is a sequence of steps. The steps begin with planning and progress to decisionmaking. This is shown along the left side of the illustration. In the sequence a problem-solver must engage in the following tasks:

—constructing questions;

—identifying, selecting, and applying skills; and

—creating tangible products which contain answers to the questions.



This is shown across the top of the illustration.

Since the model is organized into a sequence of steps with specific tasks for each step, you can isolate each step for instruction. Once a student learns the tasks for each step, the student will be able to use them, either deliberately or automatically, to solve new problems.

QUESTIONS

The problem-solver should construct many precise questions that will help clarify the problem and the steps that must be taken to solve it. This may be done in a brainstorming-style activity. The student should view each precise question as a little piece of the problem to be solved. There is no need initially for the student to organize the questions. That task is part of the planning step.

SKILLS

The problem-solver can obtain an answer to each precise question by applying appropriate skills. Students should be taught to select and apply the best skills for the specific task implied by the question.

PRODUCTS

The problem-solver creates a tangible product by applying the appropriate skills to the specific task. For example, by applying the skill of recording data, the problem-solver may create the tangible product of a chart or graph. The tangible product contains an answer to the question.

PLANNING—A problem-solver uses a sequence of focus questions to construct and organize the precise questions (see the focus questions in (#3)).

Students should be taught that when they construct a plan, they must always assume that the plan may have to be revised in light of new information.

OBTAINING DATA — The problem-solver gathers data that may have an impact on the solution to the problem. Quantitative as well as qualitative data may be needed.

ORGANIZING DATA — The problem-solver establishes some pattern of order or form with the data obtained.

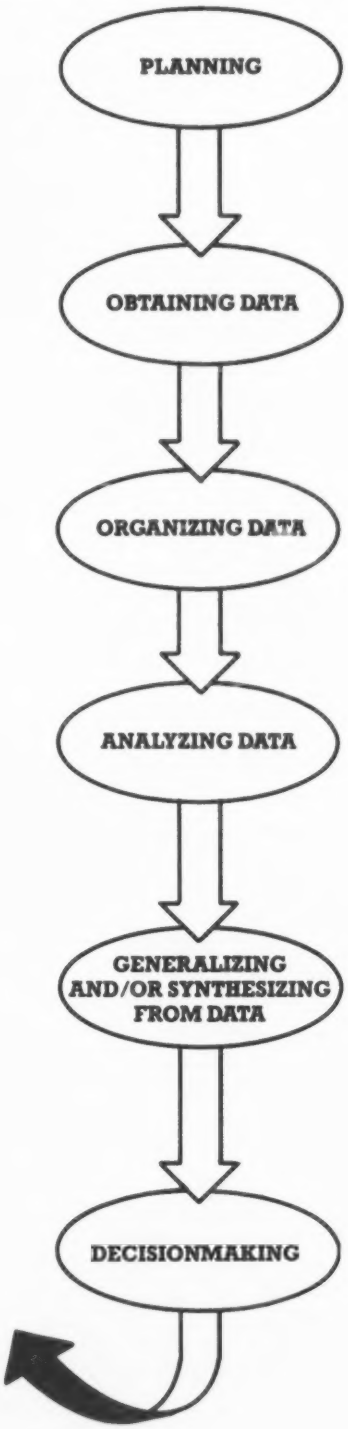
ANALYZING DATA — This step requires that the problem-solver seek apparent patterns and relationships in the data to recognize characteristics that suggest cause and effect and to state inferences.

GENERALIZING AND/OR SYNTHESIZING FROM DATA — Here, the problem-solver creates conclusions or alternative choices (potential solutions to the problem) to use in the next step, decisionmaking.

DECISIONMAKING — In the decisionmaking step, a problem-solver uses a sequence of focus questions to arrive at a decision (see the focus questions in (#3)).

Although the problem-solving model is organized into a sequence of steps that have a logical progression, it is important to note that, in practice, problem-solvers often move back-and-forth among the steps as a problem is worked on. For example, a need to reorganize the data may not become apparent until the data are analyzed. Or a problem-solver may realize as the data are being analyzed that additional data must be obtained.

3. Examples of Questions, Skills, and Products in the Problem-Solving Model

STEPS	FOCUS QUESTIONS/QUESTION STEMS
	1. What is the problem? 2. What background information do I already have? • What do I already know about ...? 3. What new information do I need? 4. What procedure or experimental design do I need to follow? • How can I find what I need to know about ...? 5. How will I know when I have solved the problem?
	What information is needed? • What are the properties of ...? • What kinds of ...? • How long, wide, big ...is it? • How much does it weigh? • What color is it? • How hot is ...?
	In what useful way(s) can the information be organized? • Which ones belong to this group? • In what order do these ... belong? • What categories are there? • How can this be graphed? • What is the result of this ... calculation?
	What useful analyses can be made of the organized information? • In what way does ... compare/contrast with ...? • What seemed to be the effect of ...? • What seemed to cause ...? • What must have been the pattern (sequence) of events? • What assumptions were made?
	What can be drawn from the analyses of information? • How can I explain ...? • How can I show I need to ...? • What is the principle of ...? • If this continues, then what is likely to happen? • What might happen if I ...? • What model shows what we know about ...? • What new problems does this suggest? • How does ...apply to ...?
	1. What decision needs to be made? 2. What are the alternative choices and the reasons for each? 3. What are the consequences of each alternative? 4. Who will be affected by each possible choice and in what way? 5. What values are directly related to each choice, and how do they relate to it? 6. Which choice is the best choice?

SKILLS	PRODUCTS
• Recognizing a problem • Communicating information • Creating models • Formulating hypotheses • Designing experimental procedures	1. A statement of the problem 2. List of facts (background information) 3. List of questions (related to later steps in the process) 4. An experimental design 5. Sketch or description of the expected (predicted) final product
• Selecting instruments • Measuring • Observing • Recording data	• Collections • Counts • Lists • Photographs • Sketches • Tape recordings
• Processing data • Creating models	• Calculations or computations • Charts, tables • Diagrams, scale drawings • Graphs • Groups, categories of information • Outline • Sorted objects
• Interpreting data • Interpolating and extrapolating	• Description of a pattern or sequence • Statements of cause and effect relationships • Statements of similarities and differences • Summary
• Evaluating hypotheses • Creating models • Formulating hypotheses • Generalizing	• A model or simulation • A new hypothesis • A new prediction, problem, theory • Applications to new situations • Statements of principles • Statements which accept or reject hypotheses • Written report
• Acquiring information • Communicating information • Making decisions • Manipulating ideas • Questioning	1. Statement of the decision to be made 2. List of alternative choices, supported by reasons 3. List of consequences of each alternative 4. List of persons directly affected by each choice and the way each is affected 5. List of values related to each choice, supported by statements of how the values relate 6. A personal choice, supported by defendable reasons for the choice